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# Compendium Of NASA Data Base For The Global Tropospheric Experiment's Pacific Exploratory Mission West-A (PEM West-A)

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(NASA-TM-109177) COMPENDIUM OF  
NASA DATA BASE FOR THE GLOBAL  
TROPOSPHERIC EXPERIMENT'S PACIFIC  
EXPLORATORY MISSION WEST-A (PEM  
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COMPENDIUM OF NASA DATA BASE FOR THE  
GLOBAL TROPOSPHERIC EXPERIMENT'S  
PACIFIC EXPLORATORY MISSION WEST-A (PEM WEST-A)

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SUMMARY

The report provides a compendium of NASA aircraft data that are available from NASA's Global Tropospheric Experiment's (GTE) Pacific Exploratory Mission West-A (PEM West-A) conducted in September and October 1991. The NASA PEM West experiments (PEM West-A and -B) are a major component of the East Asia/North Pacific Regional Study (APARE), a project within the International Global Atmospheric Chemistry (IGAC) Program. PEM West flight experiments focused on the Pacific rim region and were primarily based at Japan, Hong Kong, and Guam. The broad objectives of the experiments were to study chemical processes and long-range transport associated with Asian continental outflow over the northwest Pacific Ocean and to document the magnitude of the human impact on the oceanic/marine atmosphere over this region with an emphasis on ozone and sulfur chemistry (gas). PEM West-B, conducted in the same region during February and March 1994, studied late-winter to early-spring meteorology during which continental outflow was enhanced in comparison to outflow during the early-fall PEM West-A time frame. Results from PEM West-B will become publicly available in the summer of 1995. PEM West-A data are public domain.

The format of this compendium utilizes data plots--time series and altitude profiles--of selective data acquired aboard the NASA/Ames DC-8 aircraft during PEM West-A. The purpose of this document is to provide a representation of aircraft data that are available in archived format via NASA Langley's Distributed Active Archive Center (DAAC). The data format is not

intended to support original research/analyses, but to assist the reader in identifying data that are of interest. This compendium is for only the NASA aircraft data. The DAAC archived data bases include numerous supporting data including meteorological observations/products, photochemical modeling products, results from surface studies, satellite observations, and sondes releases.

## INTRODUCTION

The goal of the NASA Tropospheric Chemistry Program is to develop an understanding of the chemical cycles that control the composition of the troposphere and to assess the susceptibility of the global atmosphere to chemical change. A major component of the NASA program is the Global Tropospheric Experiment (GTE), which consists of a series of field experiments designed to (1) evaluate the capability of instrument techniques to measure, under field conditions, the minute concentrations of key chemical species in the troposphere; and (2) systematically address tropospheric chemistry issues relevant to global change, through airborne sampling expeditions, coupled with modeling and laboratory studies. GTE is primarily an aircraft-based program supplemented by ground-based measurements. Satellite data also play important roles. Space Shuttle observations of tropospheric carbon monoxide distributions have been used to plan and direct the course of expeditions, for example, over tropical rain forests and for continental outflow into the tropical Atlantic Ocean. Landsat land-surface images have facilitated the extrapolation of regional Arctic-tundra measurements into global-scale conclusions. Total Ozone Measurements from Satellites (TOMS) have helped place GTE observed ozone distributions/budgets into a global perspective (temporal and spatial) and to guide intensive aircraft studies over the tropical Atlantic Ocean. Weather data returned by environmental satellites have guided flight planning for research flights. The Distributed Active Archive Center (DAAC) data include many of the satellite, surface, and meteorological products used to support GTE missions or analyses.

The GTE airborne expeditions have focused on studies of the remote global atmosphere in order to provide well-documented baseline measurements of the unperturbed environment and to fully understand the chemical cycles underlying the natural environment. Table 1 and Figure 1 summarize GTE missions conducted through 1994. The GTE expeditions have been conducted in a diverse range of environments and with different scientific goals. The Chemical Instrument Test and Evaluation (CITE) series was designed to study

our ability to measure key tropospheric gaseous species by exposing selected instrumentation to a wide range of measurement conditions. The Atmospheric Boundary Layer Experiments (ABLE) were designed to study the emission, chemical processes, and dynamics of the boundary layer, and have been conducted over ecosystems known to have significant influence on the global troposphere. The importance of long-range transport of natural and anthropogenic emissions on the global troposphere has been investigated in the Pacific Exploratory Missions (PEM) and the Transport and Atmospheric Chemistry Experiment in the Atlantic (TRACE-A).

The GTE, managed through the Tropospheric Chemistry Program in the Mission to Planet Earth Office, NASA Headquarters, was initiated in the early 1980s. Implementation of the GTE Project is via a Project Office at the NASA Langley Research Center, Atmospheric Sciences Division.

#### SYMBOLS AND UNITS

|                                  |   |
|----------------------------------|---|
| ABLE                             | Atmospheric Boundary Layer Experiment                                   |
| APARE                            | East <u>A</u> sia/ <u>N</u> orth <u>P</u> acific <u>R</u> egional Study |
| CITE                             | Chemical Instrument Test and Evaluation                                 |
| CO                               | carbon monoxide   |
| CO <sub>2</sub>                  | carbon dioxide  |
| C <sub>2</sub> Cl <sub>4</sub>   | tetrachloroethylene   |
| CH <sub>3</sub> CCl <sub>3</sub> | methyl chloroform   |
| CH <sub>3</sub> OOH              | methyl peroxide   |
| CH <sub>3</sub> COOH             | acetic acid   |
| CH <sub>4</sub>                  | methane   |
| DAAC                             | Distributed Active Archive Center                                       |
| deg.                             | degree  |
| DMS                              | dimethyl sulfide  |
| dp                               | dew point temperature, degree Centigrade                                |

|                               |   |
|-------------------------------|---|
| Ga.Inst. of Tech.             | Georgia Institute of Technology, Atlanta, Georgia                 |
| GTE                           | Global Tropospheric Experiment                                    |
| H <sub>2</sub> O <sub>2</sub> | hydrogen peroxide   |
| HCOOH                         | formic acid   |
| HNO <sub>3</sub>              | nitric acid   |
| IGAC                          | International Global Atmospheric Chemistry Program                |
| LaRC                          | Langley Research Center   |
| N <sub>2</sub> O              | nitrous oxide   |
| NASA                          | National Aeronautics and Space Administration                     |
| NIES                          | National Institute for Environmental Studies, Japan               |
| NOAA                          | National Oceanic and Atmospheric Administration                   |
| NO                            | nitric oxide  |
| NO <sub>x</sub>               | nitrogen oxides (nitric oxide + nitrogen dioxide)                 |
| NO <sub>y</sub>               | total odd nitrogen  |
| NCAR                          | National Center for Atmospheric Research                          |
| O <sub>3</sub>                | ozone   |
| PAN                           | peroxyacetyl nitrate  |
| PEM                           | Pacific Exploratory Mission                                       |
| ppbv                          | parts-per-billion, by volume                                      |
| ppmv                          | parts-per-million, by volume                                      |
| PPN                           | peroxypropionyl nitrate   |
| pptv                          | parts-per-trillion, by volume                                     |
| Rel. Humidity                 | relative humidity, percent  |
| SO <sub>2</sub>               | sulfur dioxide  |
| T                             | air temperature, degree Centigrade                                |
| Theta                         | potential temperature, degree Kelvin                              |
| TOMS                          | Total Ozone Measurements from Satellites                          |
| TRACE-A                       | Transport and Atmospheric Chemistry Experiment in the<br>Atlantic |

|                    |  |
|--------------------|--|
| Univ.of CA, Irvine | University of California at Irvine, California         |
| Univ.of NH         | University of New Hampshire, Durham, New Hampshire     |
| Univ. of RI        | University of Rhode Island, Narragansett, Rhode Island |
| Univ.              | University   |

## PROGRAM AND DATA DESCRIPTIONS

The National Aeronautics and Space Administration's Pacific Exploratory Mission West (PEM West) is a major component of the East Asia/North Pacific Regional study (APARE), a project within the International Global Atmospheric Chemistry (IGAC) program. The broad objectives of the PEM West/APARE initiative is to study chemical processes and long-range transport over the northwest Pacific Ocean, and to estimate the magnitude of the human impact (specifically Asian continental outflow) on the marine/oceanic atmosphere of the region. Specific objectives of PEM West are (1) to investigate the atmospheric chemistry of ozone ( $O_3$ ) and its precursors over the northwest Pacific including examination of their natural budgets as well as the impact of anthropogenic sources; and (2) to investigate the atmospheric sulfur cycle over the northwest Pacific with emphasis on the relative importance and influence of continental versus marine sulfur sources.

The Pacific Ocean is, perhaps, the only major region in the Northern Hemisphere that is "relatively" free from direct anthropogenic influences. In the remote regions of the northern Pacific and in most of the southern Pacific, it should be possible to study the biogeochemical cycles of carbon, nitrogen, ozone, sulfur, and aerosols in an environment which, from a global perspective, is least perturbed by anthropogenic activities. On the other hand, there is little doubt that long-range transport of air pollutants from Asia and, to a lesser extent, Europe and North America is beginning to have significant impact on the atmosphere over a large part of the Pacific. The results from the PEM West studies provide an extensive set of baseline data



from which the anthropogenic impact of this region can be reliably assessed for decades to come.

The overall experiment design for the PEM-West/APARE program encompassed two field studies positioned in time such that contrasting meteorological regimes in the northwestern Pacific could be studied. The first phase of the Pacific Exploratory Mission West, PEM West-A, was conducted over the Pacific Ocean off the coast of Asia during September and October, 1991. Significant characteristics of the lower troposphere airflow during this time of year includes periods during which the predominance of flow is from the mid-Pacific (marine) regions and periods in which the marine flow is modified/mixed with Asian continental outflow. Phase B of PEM West was conducted during February and March 1994, a period characterized by maximum outflow from the Asian continent.

The centerpiece of PEM West-A was a series of 18 research flights with the instrumented NASA Ames DC-8. The aircraft operated from three staging areas: Yokota Air Force Base, Japan; Kai Tak International Airport, Hong Kong; and Anderson Air Force Base, Guam. Table 2 summarizes the flights, and Figure 2 shows the flight regions. Flights 6-9, 12-13, and 15-17 were site-intensive flights based from Japan, Hong Kong, and Guam, respectively. Survey/ferry flights included (a) flights 4-5 from Ames to Japan (via Anchorage, Alaska); (b) flights 10-11 from Japan to Hong Kong (via Okinawa); (c) flight 14 from Hong Kong to Guam; and (d) flights 18-21 from Guam to Ames (via Wake Island and Hawaii). Flight 20 was a Hawaiian Island flight designed in conjunction with surface sampling conducted by NOAA/NCAR at the Mauna Loa Observatory. While the prime objective of the survey/ferry flights was to move the aircraft to a new base of operation, the flight plans were designed to provide as much information on the atmospheric processes and vertical structure of the atmosphere as possible. The intensive flights were designed to take advantage of the geographical location of the site and prevailing meteorological conditions in addressing science objectives. As a result of the location of the three intensive sites (staging areas), flights covered a

latitude range of about 30° N to the Equator and sampled air with continental lifetimes of <1 day (i.e., passed over the Asian continent within 1 day of sampling) to air which had been over the Pacific Ocean for >10 days.

Special PEM West-A sampling events or targets of opportunity included (1) two "fly-bys" of Taiwan [flights 12 and 13, with flight 12 including a ground station flyby], (2) the first known airborne study of trace gases in a typhoon [flight 9--typhoon Mireille and flight 14--typhoon Orchid], and (3) the already noted Mauna Loa Observatory experiment of flight 20. Typhoon Mireille, a category 4 typhoon, struck the western side of Japan on September 27, 1991. As Mireille approached the coast of Japan, the DC-8 conducted flight 9 to study the roles of typhoons in the transport of trace gases, measuring both the inflow to the typhoon at low altitudes and the outflow within the eye at high altitudes. Sampling of typhoon Orchid, which occurred as a secondary objective of flight 14, was confined to sampling the high-altitude outflow in much lesser detail than for Mireille.

The core set of measurements aboard the aircraft focused on ozone and sulfur chemistry issues (gaseous). The aircraft data included a suite of chemical measurements which included ozone, nitric oxide, nitrogen dioxide, total odd or "reactive" nitrogen gaseous species, sulfur trace gases (sulfur dioxide, dimethyl sulfide, carbon disulfide, and carbonyl sulfide), peroxyacetyl nitrate or PAN, peroxypropionyl nitrate, methane, carbon monoxide, carbon dioxide, nonmethane hydrocarbons, fluorocarbons, acetic acid, formic acid, nitric acid, hydrogen and methyl peroxides, and aerosol number/size distribution. Table 3 identifies investigators responsible for the measurements, and Figure 3 shows a schematic of the aircraft instrument plan.

The aircraft platform as used in PEM West-A had a cruise speed at altitude of about 12 km/min and a maximum flight duration and ceiling of about 8-9 hours and 13 km, respectively. Survey flights were generally long-duration flights at high altitude (10 to 13 km) with (generally) at least one descent (spiral or ramp in addition to takeoff and landing) to about 150 to

300 m above sea level. Intensive flights combined numerous ramps, profiles, and level-flight legs to meet planned objectives. Generally, altitude profiles (spirals or ramps) were flown with ascent/descent rates of 150 to 300 m/min.

The PEM West-A DAAC data archive includes (1) data taken aboard the NASA Ames DC-8 aircraft; (2) data measured at surface sites throughout the Pacific rim basin; (3) sondes released from multiple locations in support of the aircraft flights; (4) photochemical modeling products used in analyses of results; and (5) numerous meteorological, land-use, and satellite data products used in flight (field) planning and post-mission analyses.

The data plots for the PEM West-A missions are given in Appendix A. For each flight, five pages of time series plots are provided: page 1 -- a pictorial diagram of the flight region and time series plots of altitude, temperature (T), dew point temperature (dp), relative humidity, and potential temperature (theta); page 2 -- ozone ( $O_3$ ), carbon monoxide (CO), carbon dioxide ( $CO_2$ ), methane, nitrous oxide ( $N_2O$ ), and benzene; page 3 -- nitric oxide (NO), nitrogen oxides ( $NO_x$ ), total odd or "reactive" nitrogen gas species ( $NO_y$ ), peroxyacetyl nitrate (PAN), and nitric acid; page 4 -- acetylene, ethane, propane, tetrachloroethylene ( $C_2Cl_4$ ), and methyl chloroform ( $CH_3CCl_3$ ); and page 5 -- sulfur dioxide ( $SO_2$ ), dimethyl sulfide (DMS), ethylene, hydrogen peroxide ( $H_2O_2$ ), and methyl peroxide ( $CH_3OOH$ ). The species were selected to provide the reader with information on both the source characteristics and photochemical history of the air. Figure numbers correspond to flight numbers; e.g., Figure A4.2 represents page 2 of the plots for flight #4. Selected profile plots follow the time series plots as, e.g., Figure A4.6 is the first page of profile plots for flight 4. Profile plot sets include temperature, dew point temperature, ozone, carbon monoxide, and methane data plotted to the same altitude scale. One to three sets of profile plots are provided (format of two sets per page) for each flight. Table 4 summarizes the profiles selected. There are no figures with the prefix of A1, A2, or A3. Flights 1 to 3 were instrument checkout flights

based at Ames and data were not archived. Data plots are in standardized format as discussed in Appendix A. The DAAC archive includes measurements aboard the DC-8 aircraft during PEM West-A which are not plotted in Appendix A.

## CONCLUDING REMARKS

This compendium of data from NASA's Global Tropospheric Experiment's Pacific Exploratory Mission West-A provides only a representation of aircraft data that are available in archived format from NASA Langley's Distributed Active Archive Center (DAAC). The presented data are not intended to support original research/analyses, but serve as an overview of the PEM West-A data and provide some assistance to the reader in identifying data that are of interest and which may be obtained from Langley's DAAC archive. This compendium covers only selected NASA DC-8 aircraft data. The archived data bases include other data measured on board the aircraft as well as numerous supporting data including meteorological observations/products, photochemical modeling products, surface station observations, satellite observations, and sondes releases. GTE-sponsored analyses/results from the PEM West-A expeditions have been accepted for a Special Issue of the Journal of Geophysical Research - Atmospheres scheduled for publication in 1995.

Questions or information regarding the Langley DAAC archive should be directed to Langley DAAC User and Data Services, Mail Stop 157B, NASA Langley Research Center, Hampton, Virginia 23681-0001. A brief description of the DAAC, log on procedures, and data bases is given as Appendix B.

TABLE 1. GTE Field Expeditions

| Expedition | Date | General Geographic Region   | Time of Year                  |
|------------|------|---|-------------------------------|
| ABLE-1     | 1984 | Barbados, French Guyana   | June                          |
| ABLE-2A    | 1985 | Amazon Basin  | August                        |
| ABLE-2B    | 1987 | Amazon Basin  | May                           |
| ABLE-3A    | 1988 | Alaska--Barrow, Bethel, Cold Bay  | July/August                   |
| ABLE-3B    | 1990 | Canada--Hudson Bay, Schefferville   | July/August                   |
| CITE-1     | 1983 | Hawaii  | November                      |
| CITE-1     | 1984 | Eastern North Pacific--off the California coast                                 |                               |
| CITE-2     | 1986 | Western USA   | April                         |
| CITE-3     | 1989 | Western North Atlantic--Virginia coast and Western South Atlantic--Brazil coast | August<br>August<br>September |
| PEM West-A | 1991 | Western Pacific Rim   | October                       |
| PEM West-B | 1994 | Western Pacific Rim   | Feb./March                    |
| TRACE-A    | 1992 | Brazil, South Atlantic, southwest Africa  | September                     |

TABLE 2. Summary of the Flights Conducted during the 1991 PEM West-A Expedition  
(All times are GMT)

| Mission<br>Number | Flight Date  | Departure |                   | Arrival |                   | Purpose   |
|-------------------|--------------|-----------|-------------------|---------|-------------------|---|
|                   |              | Time      | Location          | Time    | Location          |   |
| 4                 | Sept. 16     | 1704      | NASA Ames         | 2251    | Anchorage, Alaska | survey & ferry  |
| 5                 | Sept. 17-18* | 1857      | Anchorage, Alaska | 0328    | Yokota, Japan     | survey & ferry  |
| 6                 | Sept. 22     | 0224      | Yokota, Japan     | 0947    | Yokota, Japan     | background marine air   |
| 7                 | Sept. 24     | 0213      | Yokota, Japan     | 0915    | Yokota, Japan     | continental outflow   |
| 8                 | Sept. 25-26  | 1657      | Yokota, Japan     | 0017    | Yokota, Japan     | diurnal photochemistry  |
| 9                 | Sept. 27     | 0105      | Yokota, Japan     | 0739    | Yokota, Japan     | typhoon Mireille  |
| 10                | Oct. 1       | 0244      | Yokota, Japan     | 0935    | Okinawa           | survey & ferry  |
| 11                | Oct. 2       | 0002      | Okinawa           | 0223    | Hong Kong         | survey & ferry  |
| 12                | Oct. 4       | 0152      | Hong Kong         | 1015    | Hong Kong         | continental outflow & Taiwan flyby                                |
| 13                | Oct. 6       | 0119      | Hong Kong         | 0815    | Hong Kong         | continental outflow   |
| 14                | Oct. 8       | 0148      | Hong Kong         | 1002    | Guam              | survey & ferry, typhoon Orchid                                    |
| 15                | Oct. 11-12   | 2351      | Guam              | 0729    | Guam              | marine, southeast of Guam   |
| 16                | Oct. 13      | 0040      | Guam              | 0814    | Guam              | marine, southwest of Guam   |
| 17                | Oct. 14-15   | 1810      | Guam              | 0209    | Guam              | diurnal photochemistry, west of Guam                              |
| 18                | Oct. 17-18   | 2344      | Guam              | 0337    | Wake Island       | survey & ferry  |
| 19                | Oct. 18-19*  | 2202      | Wake Island       | 0339    | Hawaii            | survey & ferry  |
| 20                | Oct. 20      | 1348      | Hawaii            | 1947    | Hawaii            | intercomparison with Mauna Loa<br>Observatory ground measurements |
| 21                | Oct. 21-22   | 1933      | Hawaii            | 0113    | NASA Ames         | survey & ferry  |

\* Crossed International date line

TABLE 3. Principal Investigators and Institutions Participating in  
Pacific Exploratory Mission West-A

| Investigator   | Institution  | Investigation/Measurement   |
|----------------|--|---|
| Bruce Anderson | NASA Langley Research Center                       | carbon dioxide  |
| Alan Bandy     | Drexel University                                  | trace sulfur gases  |
| John Barrick   | NASA Langley Research Center                       | airborne meteorological/position data   |
| John Bradshaw  | Georgia Institute of Technology                    | nitric oxide, nitrogen dioxide, total oxides of nitrogen                        |
| Edward Browell | NASA Langley Research Center                       | ozone & aerosol profiles (remote sensor)  |
| Gerald Gregory | NASA Langley Research Center                       | ozone, aerosols (in situ)   |
| Brian Heikes   | University of Rhode Island                         | H <sub>2</sub> O <sub>2</sub> , CH <sub>3</sub> OOH                             |
| Kenneth Kelly  | NOAA Boulder Laboratory                            | water vapor   |
| Yutaka Kondo   | Nagoya University, Japan                           | nitric oxide, total oxides of nitrogen  |
| Sherry Rowland | University of California, Irvine                   | nonmethane hydrocarbons   |
| Glen Sachse    | NASA/Langley Research Center                       | carbon monoxide, methane, nitrous oxide   |
| Fumio Sakamaka | National Institute for Environmental Health, Japan | nonmethane hydrocarbons   |
| Hanwant Singh  | NASA Ames Research Center                          | PAN, PPN, C <sub>2</sub> Cl <sub>4</sub>  |
| Robert Talbot  | University of New Hampshire                        | HNO <sub>3</sub> , HCOOH, CH <sub>3</sub> COOH, aerosol composition (elemental) |

TABLE 4. PEM West-A Profiles

| Flight | Date         | Time | Latitude, °N | Longitude, °E |
|--------|--------------|------|--------------|---------------|
| 4      | September 16 | 1715 | 38.4         | -122.6        |
| 4      | September 16 | 1930 | 50.0         | -137.4        |
| 4      | September 16 | 2130 | 55.7         | -153.4        |
| 5      | September 16 | 1900 | 60.8         | -150.9        |
| 5      | September 16 | 2215 | 52.5         | 176.2         |
| 5      | September 17 | 0300 | 36.6         | 140.7         |
| 6      | September 22 | 0415 | 29.1         | 148.5         |
| 6      | September 22 | 0830 | 29.6         | 147.6         |
| 7      | September 24 | 0300 | 35.1         | 144.7         |
| 7      | September 24 | 0815 | 36.8         | 144.8         |
| 8      | September 25 | 1930 | 30.1         | 147.1         |
| 8      | September 25 | 2200 | 27.9         | 147.0         |
| 9      | September 27 | 0400 | 29.0         | 134.3         |
| 9      | September 27 | 0730 | 35.3         | 138.6         |
| 10     | October 1    | 0300 | 34.7         | 139.6         |
| 10     | October 1    | 0700 | 19.3         | 126.0         |
| 10     | October 1    | 0915 | 25.4         | 126.9         |
| 11     | October 2    | 0015 | 25.3         | 127.0         |
| 11     | October 2    | 0215 | 21.7         | 114.8         |
| 12     | October 4    | 0900 | 21.9         | 120.4         |
| 13     | October 6    | 0445 | 29.3         | 126.2         |
| 13     | October 6    | 0645 | 23.4         | 119.1         |

Times are GMT



TABLE 4. Profiles continued.

| Flight | Date       | Time | Latitude, °N | Longitude, °E |
|--------|------------|------|--------------|---------------|
| 14     | October 8  | 0200 | 21.6         | 115.0         |
| 14     | October 8  | 0700 | 17.0         | 128.0         |
| 14     | October 8  | 0945 | 14.2         | 144.1         |
| 15     | October 12 | 0315 | 0.4          | 161.7         |
| 15     | October 12 | 0715 | 13.2         | 145.5         |
| 16     | October 13 | 0400 | 4.1          | 124.9         |
| 16     | October 13 | 0800 | 13.5         | 144.9         |
| 17     | October 14 | 2015 | 15.0         | 142.0         |
| 17     | October 14 | 2300 | 14.9         | 139.5         |
| 17     | October 15 | 0200 | 14.1         | 144.1         |
| 18     | October 18 | 0115 | 12.9         | 155.8         |
| 18     | October 18 | 0230 | 13.1         | 162.9         |
| 18     | October 18 | 0330 | 18.8         | 166.2         |
| 19     | October 19 | 0100 | 15.8         | -175.3        |
| 19     | October 19 | 0315 | 20.9         | -159.1        |
| 20     | October 20 | 1545 | 18.6         | -155.4        |
| 21     | October 21 | 1930 | 21.3         | -157.6        |

Times are GMT



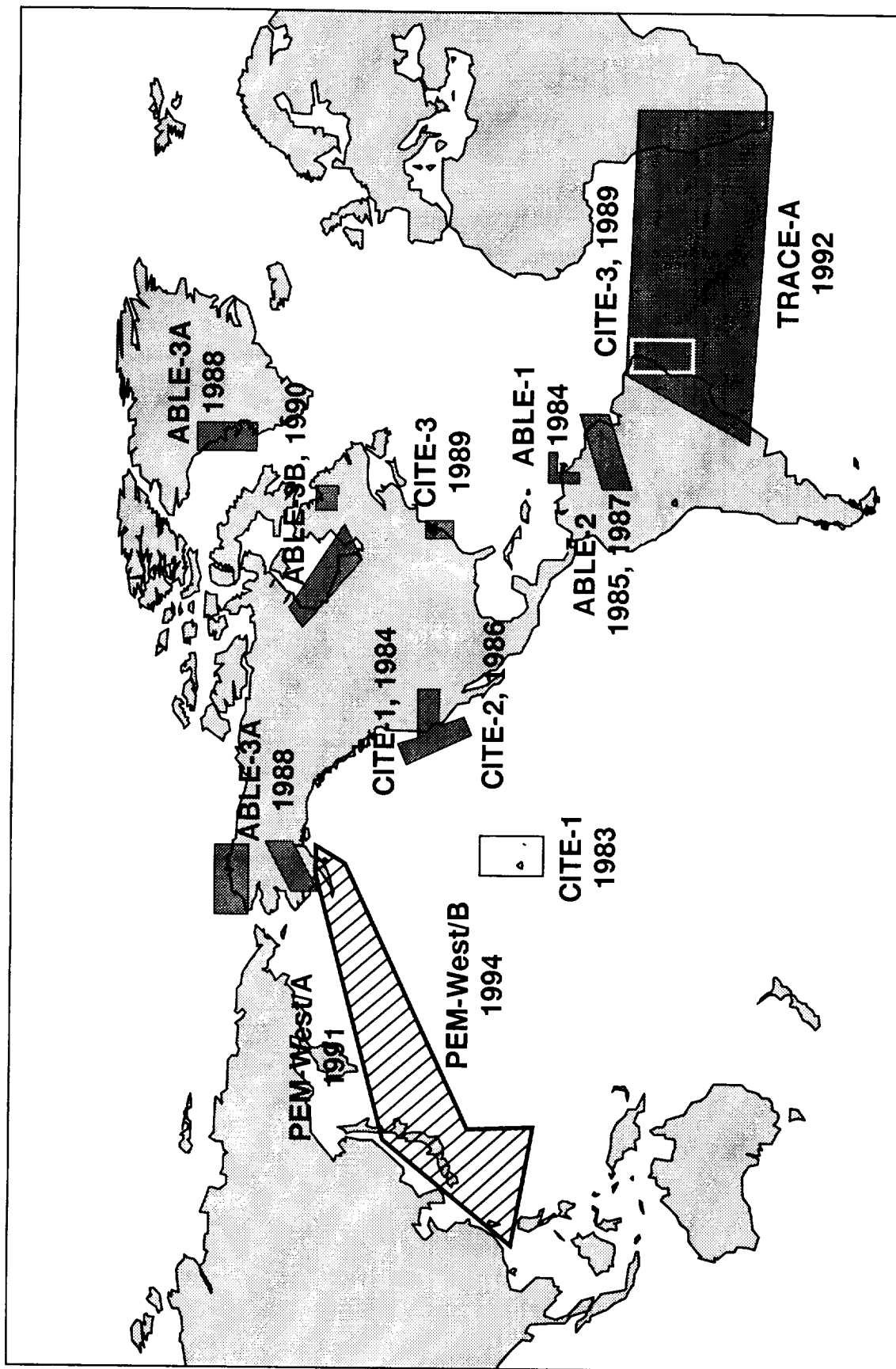


Figure 1. GTE mission sites.

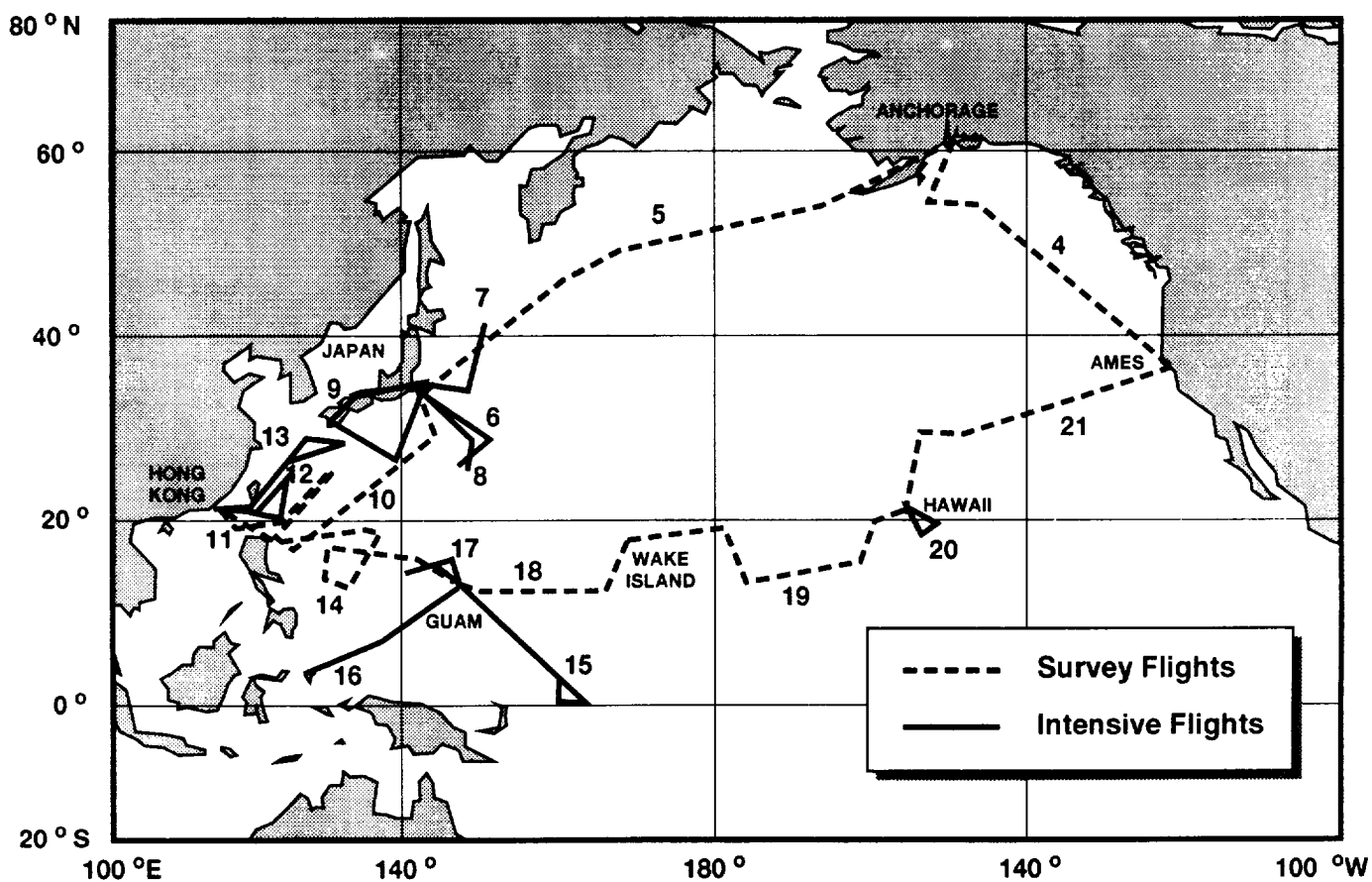
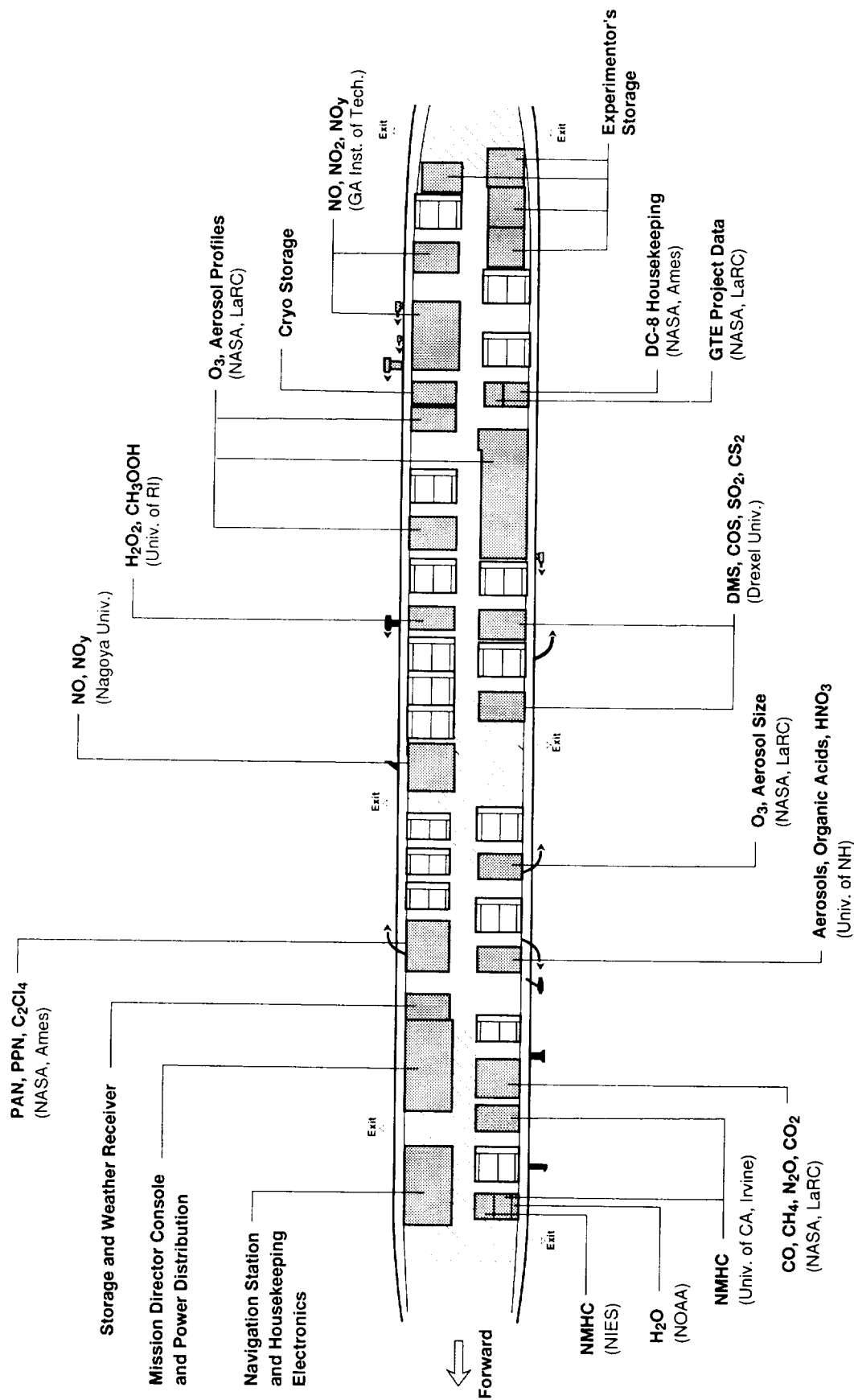


Figure 2. Flight tracks for the DC-8 aircraft during the PEM West-A mission.



**Figure 3. Instrumentation location on the NASA DC-8 aircraft during PEM West-A mission.**



## APPENDIX A: PEM WEST-A DATA PLOTS

Plots are presented in a standardized format, and the data (unedited) are from the Langley DAAC archive. Relative humidity and potential temperature are calculated from measurements made on the aircraft. In some cases (mostly for moist, boundary layer conditions) relative humidity may exceed 100% (not plotted) as dew point temperature exceeded air temperature by a few degrees (assumed to be the result of instrument measurement/calibration uncertainty). For time series plots, abscissa time scales for a given flight are identical, and ordinate scales (for a given parameter) are identical among all flights. Ordinate scales were selected to best represent all the data for a specie measured during the expedition; thus, some data may be off-scale. As a result of the software used for the plots and the data archive use of codes (in place of valid data) for data taken (1) during instrument calibration, (2) when measurements were at "detection limit," and/or (3) when measurements were invalid, it is sometimes difficult to distinguish from the plots if data are off-scale or coded as invalid. For example, a symbol without an attached line may either mean that adjacent data are off-scale or have been coded as invalid. Inspection of the other plotted data often provides information which resolves the uncertainty. For profile plots, altitude scales are identical for all plots and the specie scales are those selected for the time series plots. In order to maintain the standardized format, plots for flights in which a specie data were not reported are plotted with the axes and a "NO DATA" entry.

Given below are the beginning page numbers for each flight's sequence of plots:

Flight 4 - page 23  
Flight 5 - page 31  
Flight 6 - page 39  
Flight 7 - page 45  
Flight 8 - page 51

Page 20

Flight 9 - page 57  
Flight 10 - page 63  
Flight 11 - page 71  
Flight 12 - page 77  
Flight 13 - page 83  
Flight 14 - page 89  
Flight 15 - page 97  
Flight 16 - page 103  
Flight 17 - page 109  
Flight 18 - page 117  
Flight 19 - page 125  
Flight 20 - page 131  
Flight 21 - page 137



# PEM (A) PACIFIC MISSION: FLIGHT 4

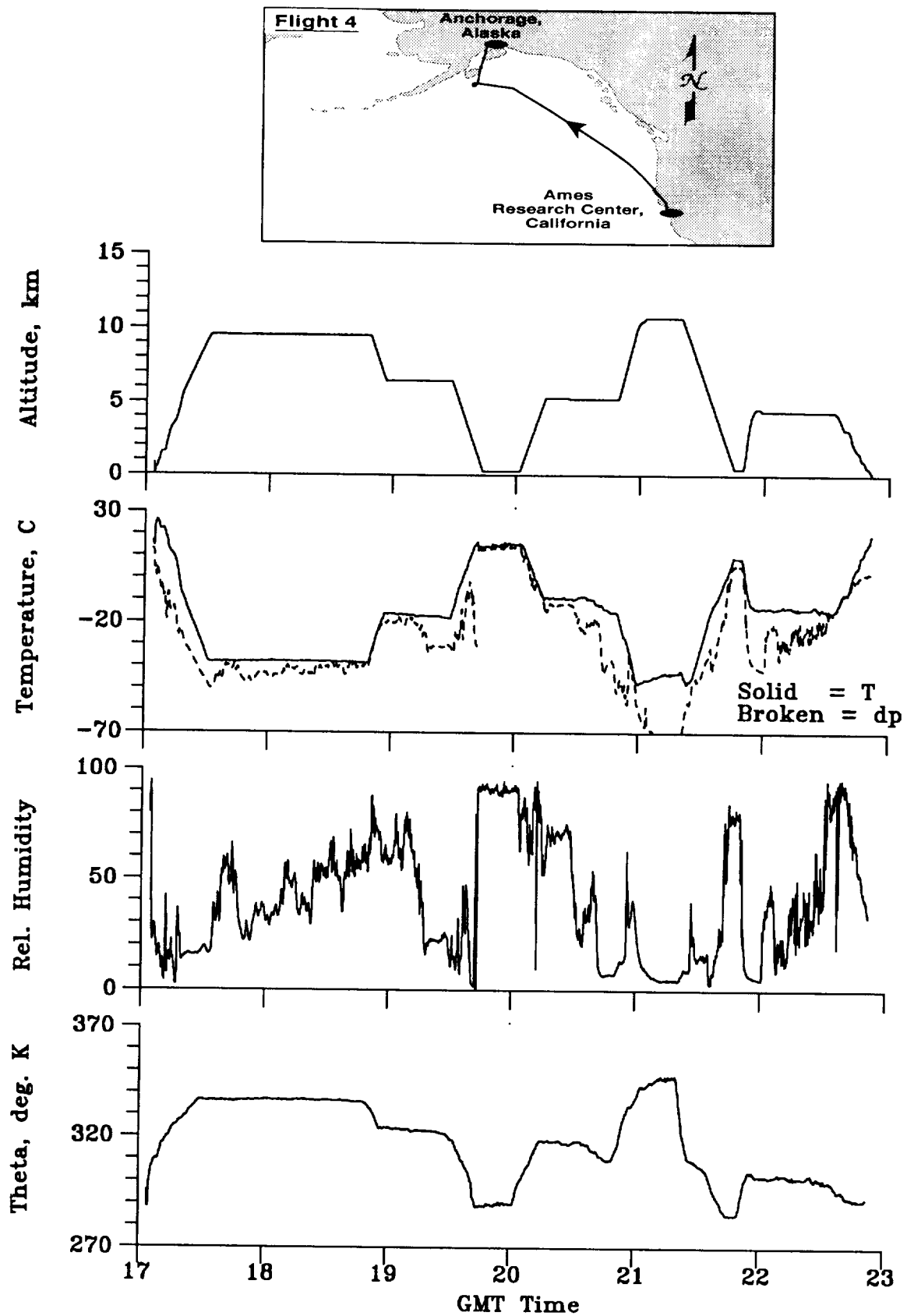


Figure A4.1

# PEM (A) PACIFIC MISSION: FLIGHT 4

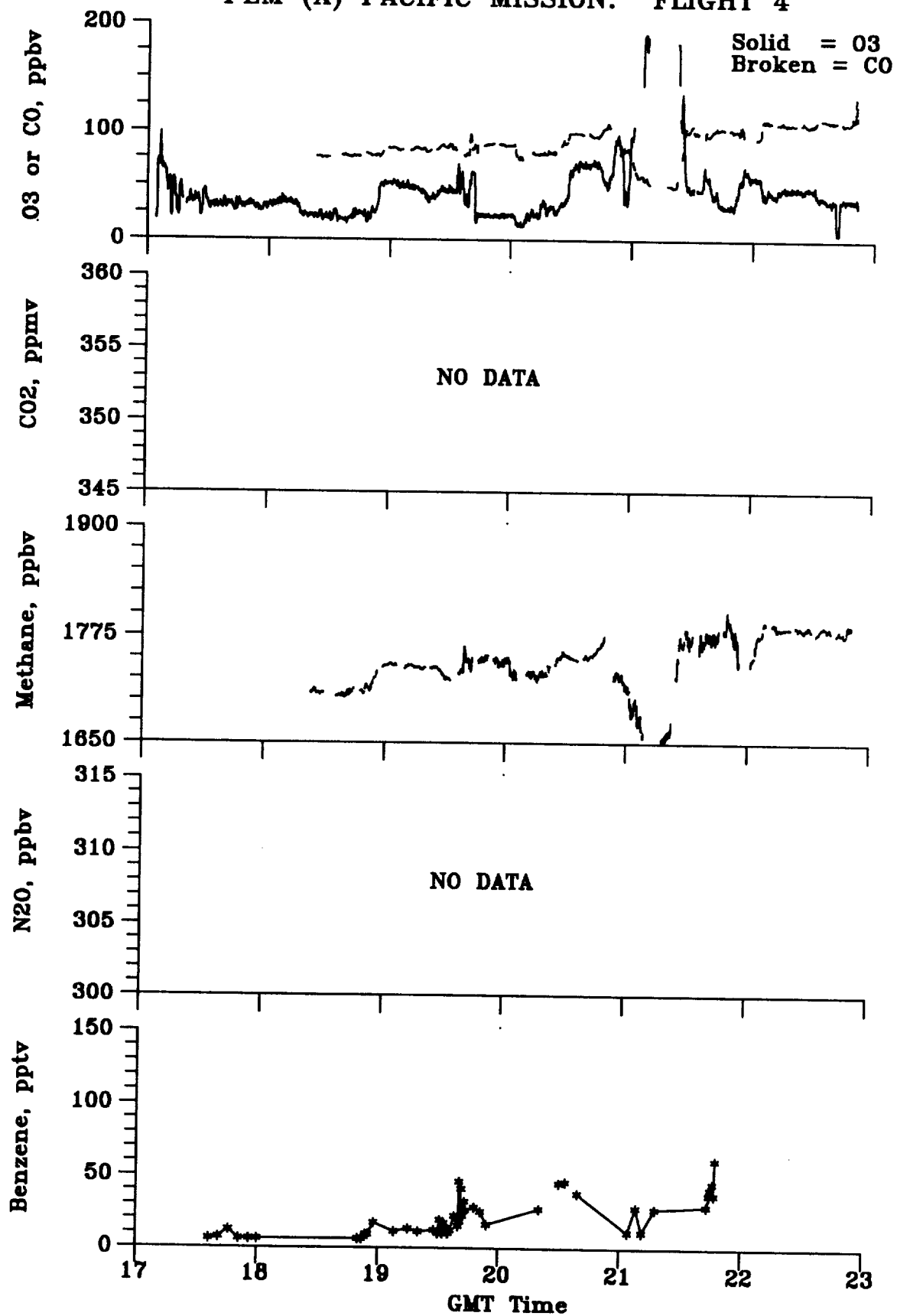


Figure A4.2

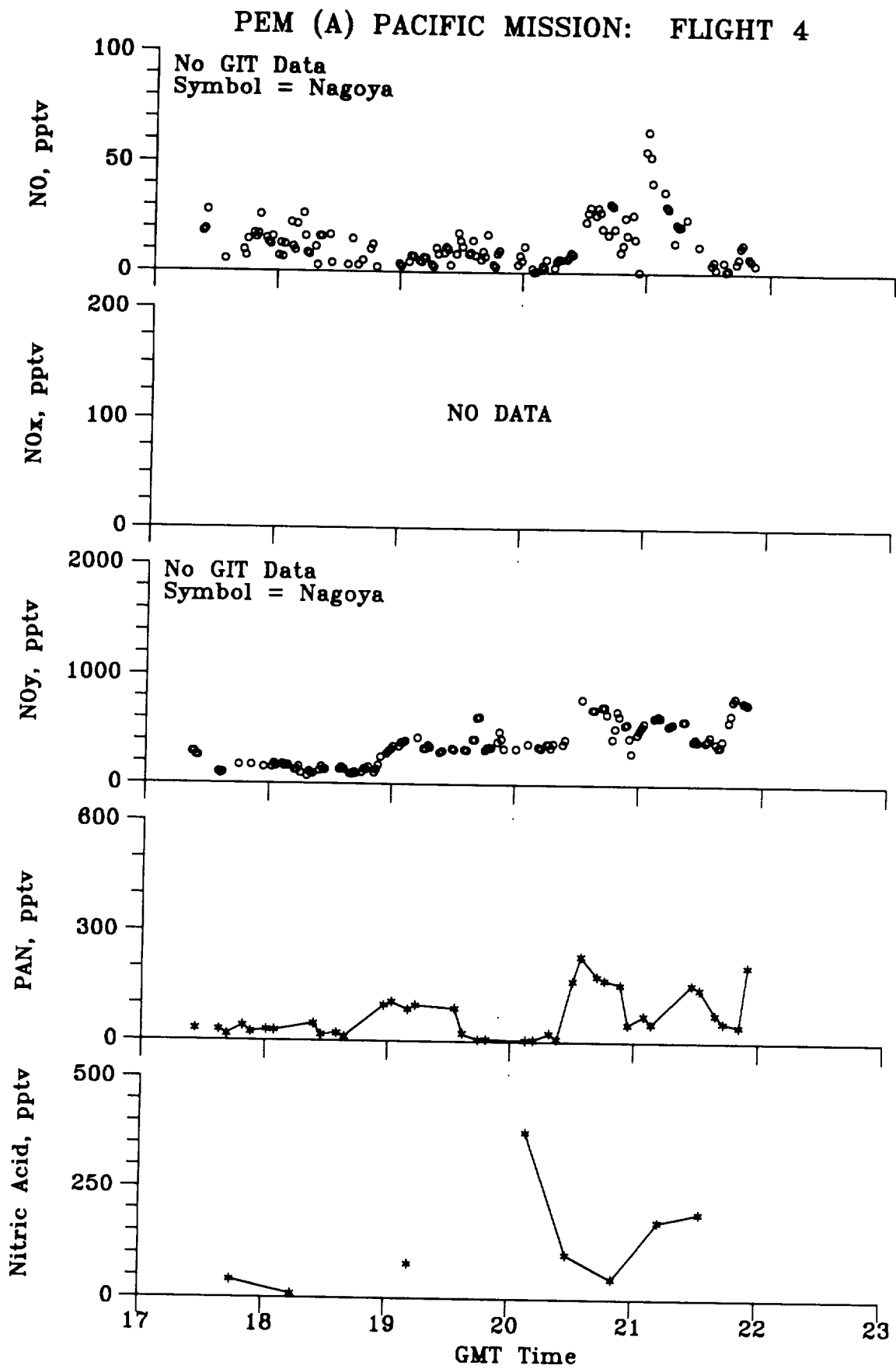


Figure A4.3

# PEM (A) PACIFIC MISSION: FLIGHT 4

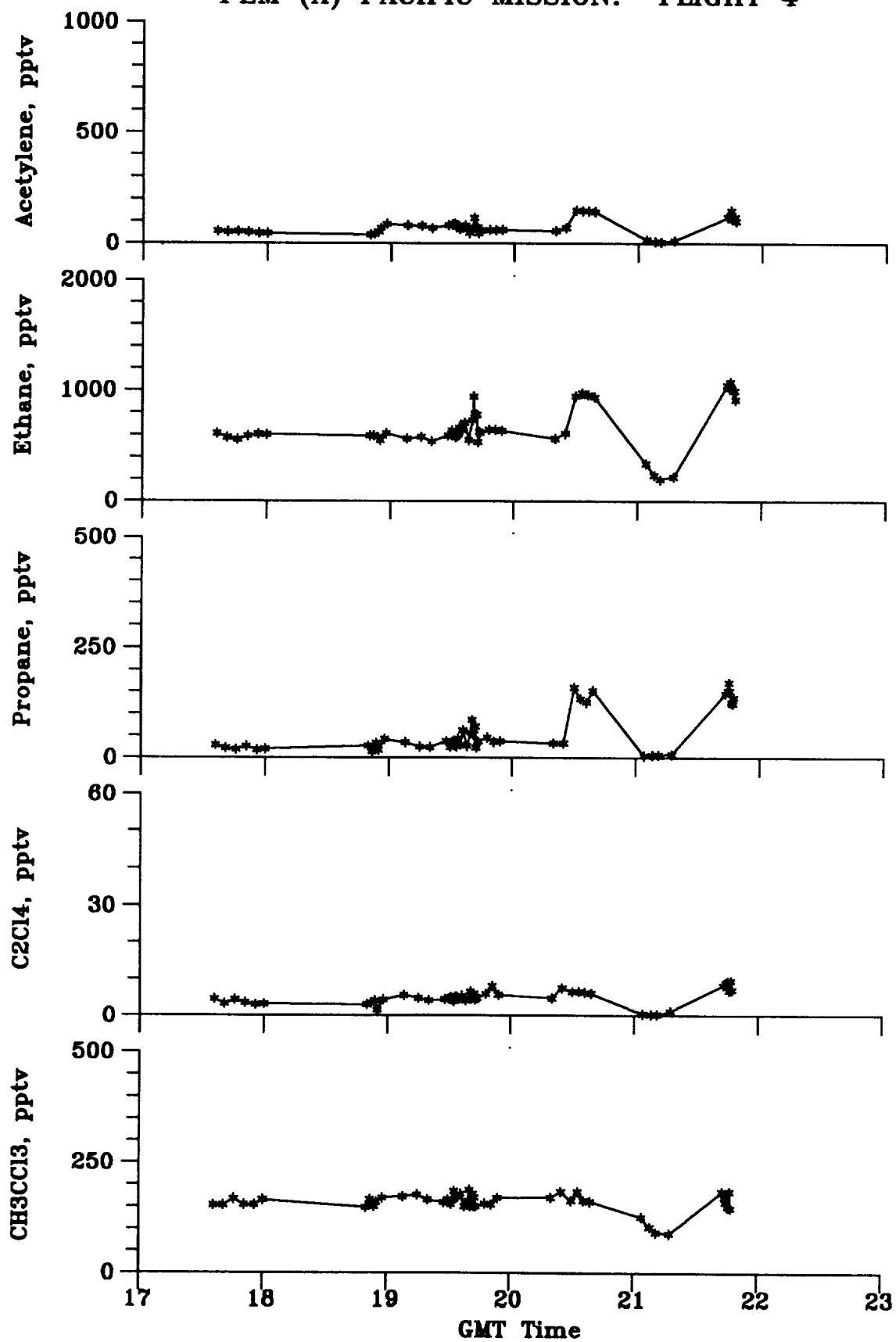


Figure A4.4

# PEM (A) PACIFIC MISSION: FLIGHT 4

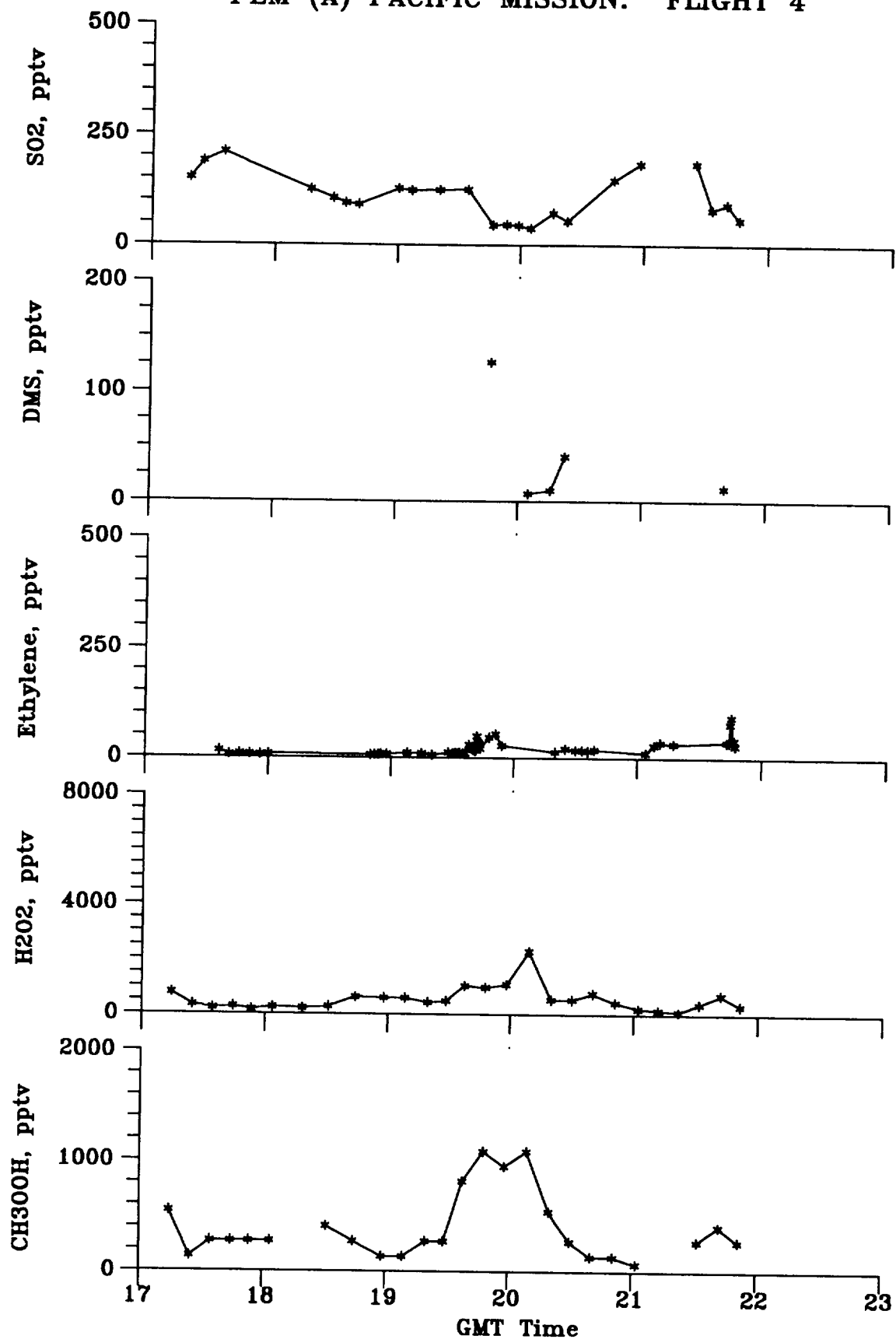
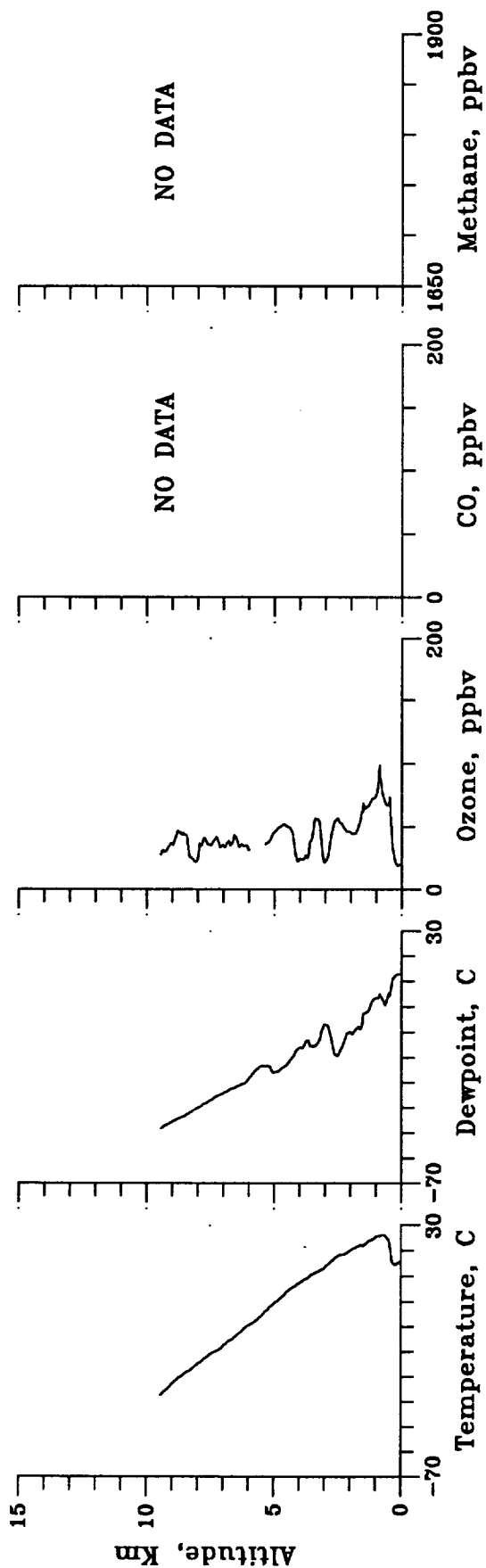


Figure A4.5

PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 1715 GMT



PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 1930 GMT

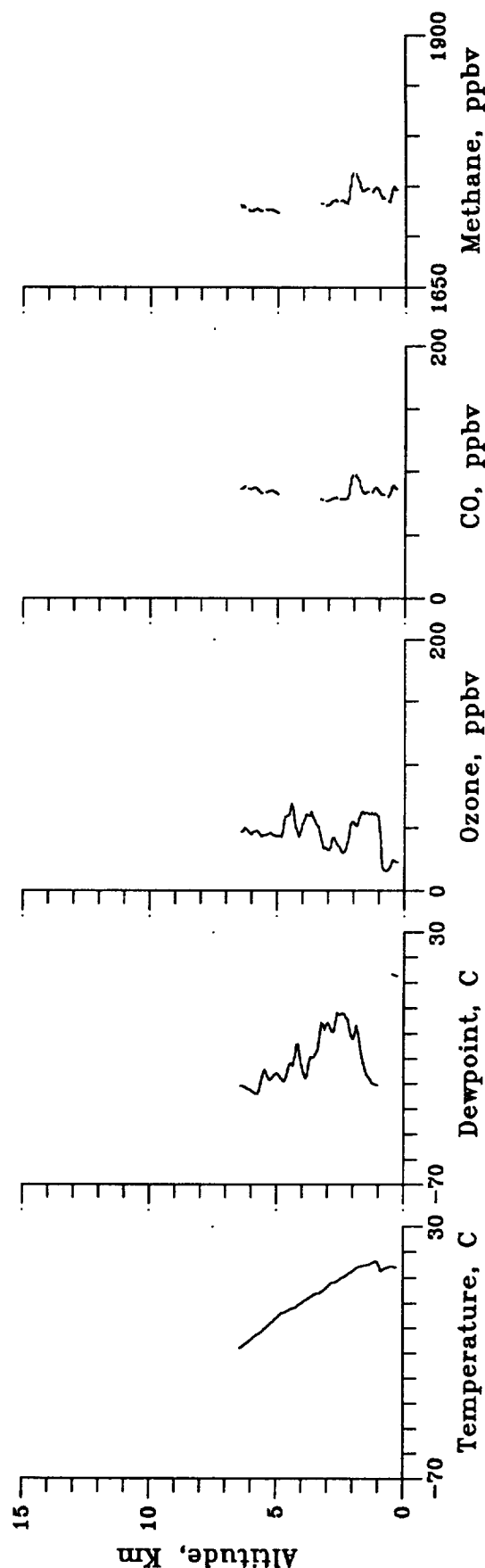


Figure A4.6

PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 2130 GMT

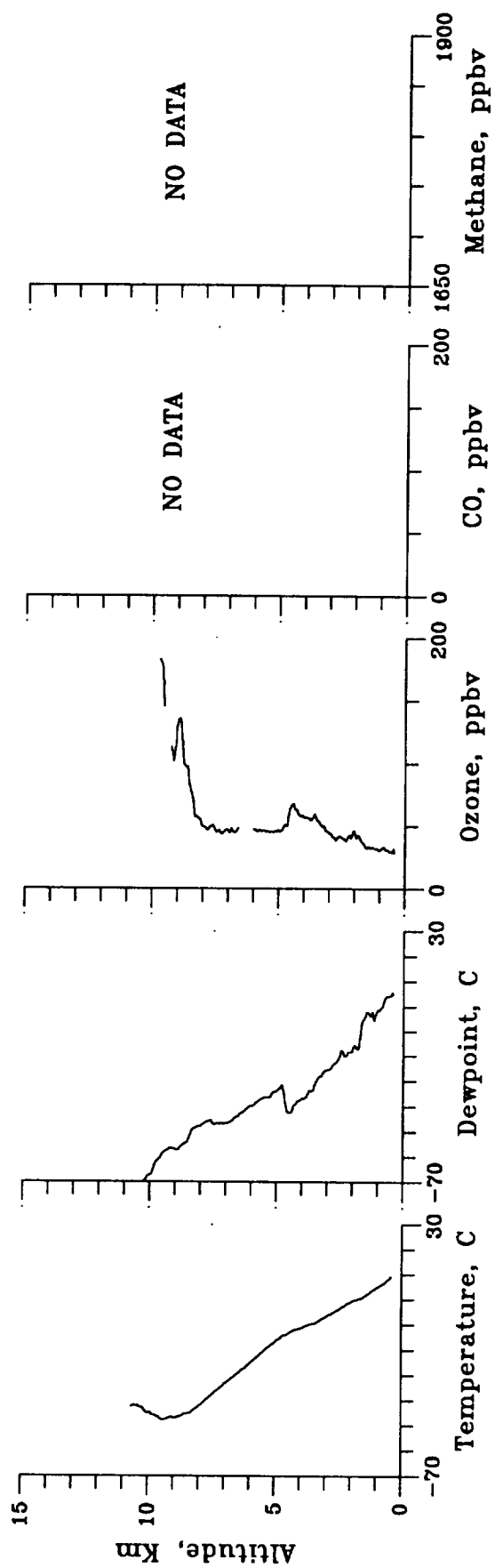


Figure A4.7





# PEM (A) PACIFIC MISSION: FLIGHT 5

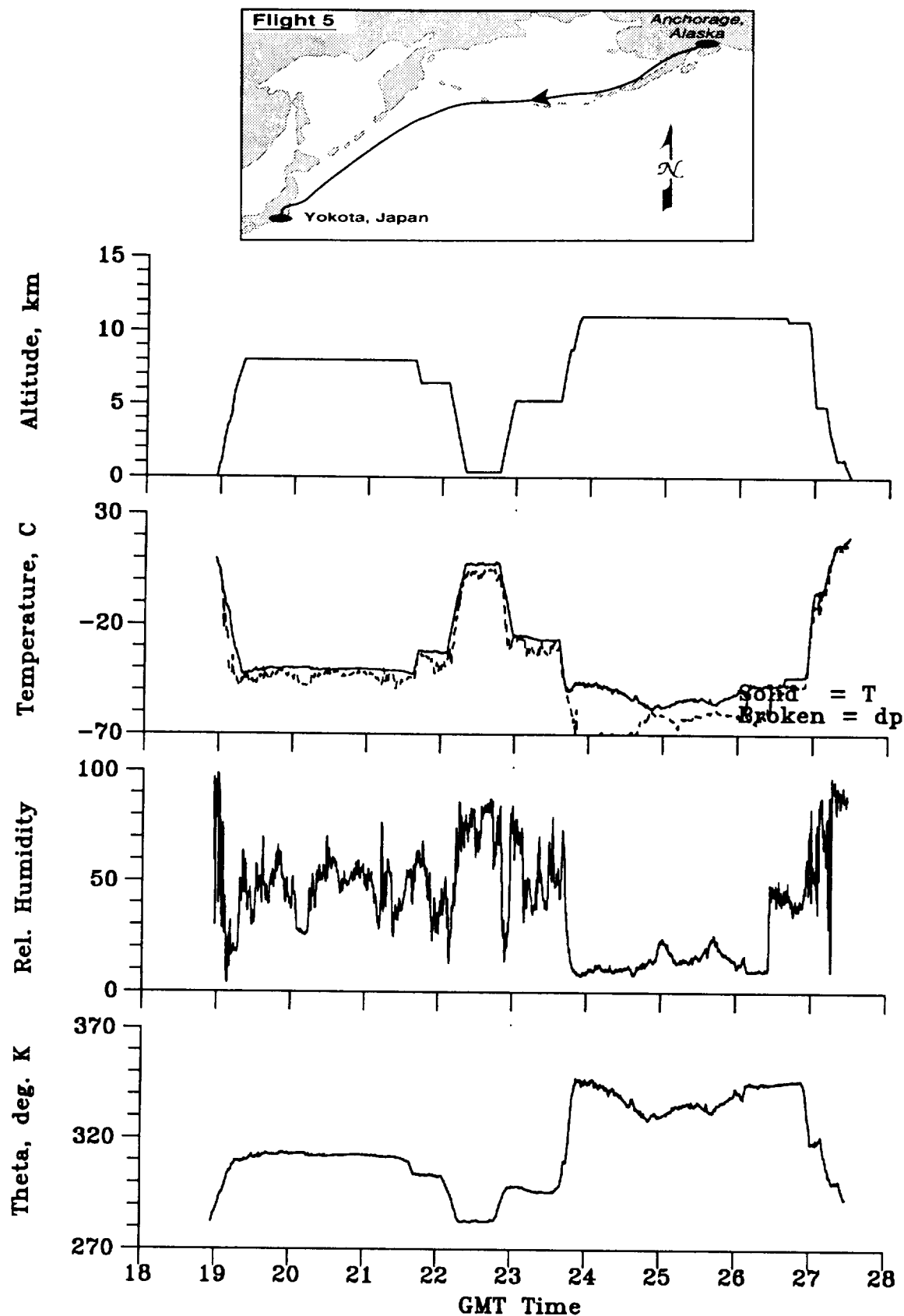


Figure A5.1 PRECEDING PAGE MARKED TO

30

# PEM (A) PACIFIC MISSION: FLIGHT 5

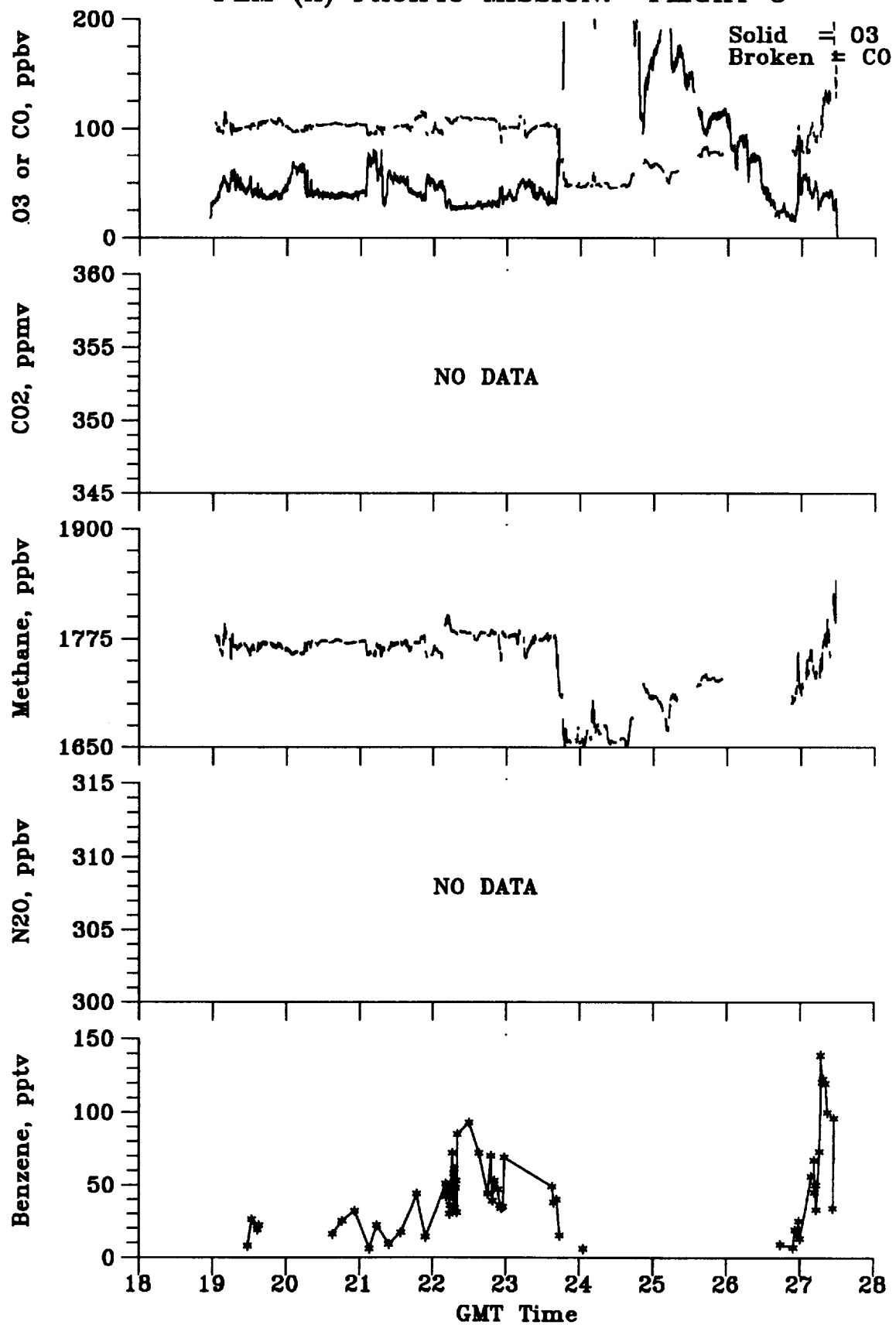


Figure A5.2

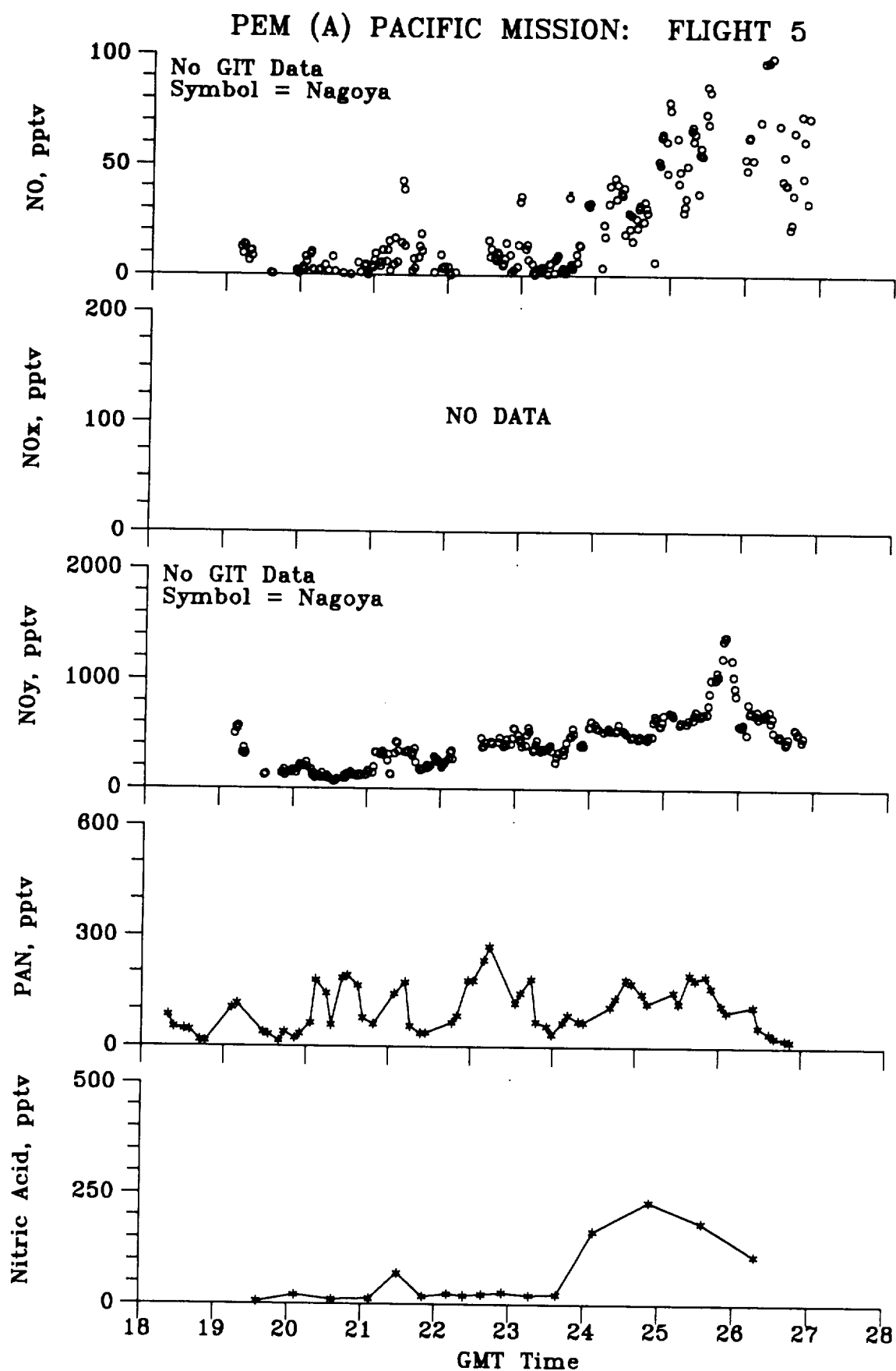


Figure A5.3

# PEM (A) PACIFIC MISSION: FLIGHT 5

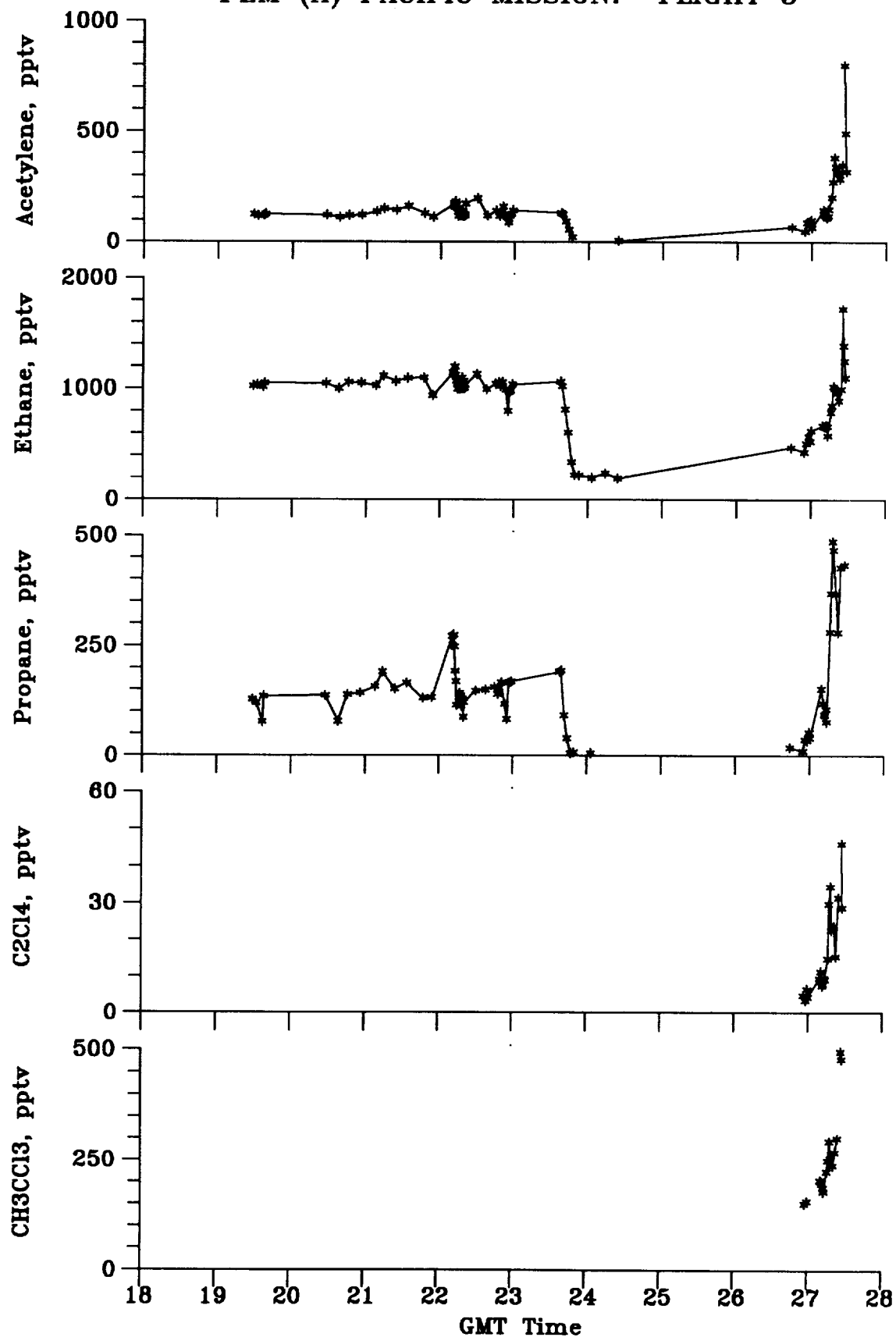


Figure A5.4

# PEM (A) PACIFIC MISSION: FLIGHT 5

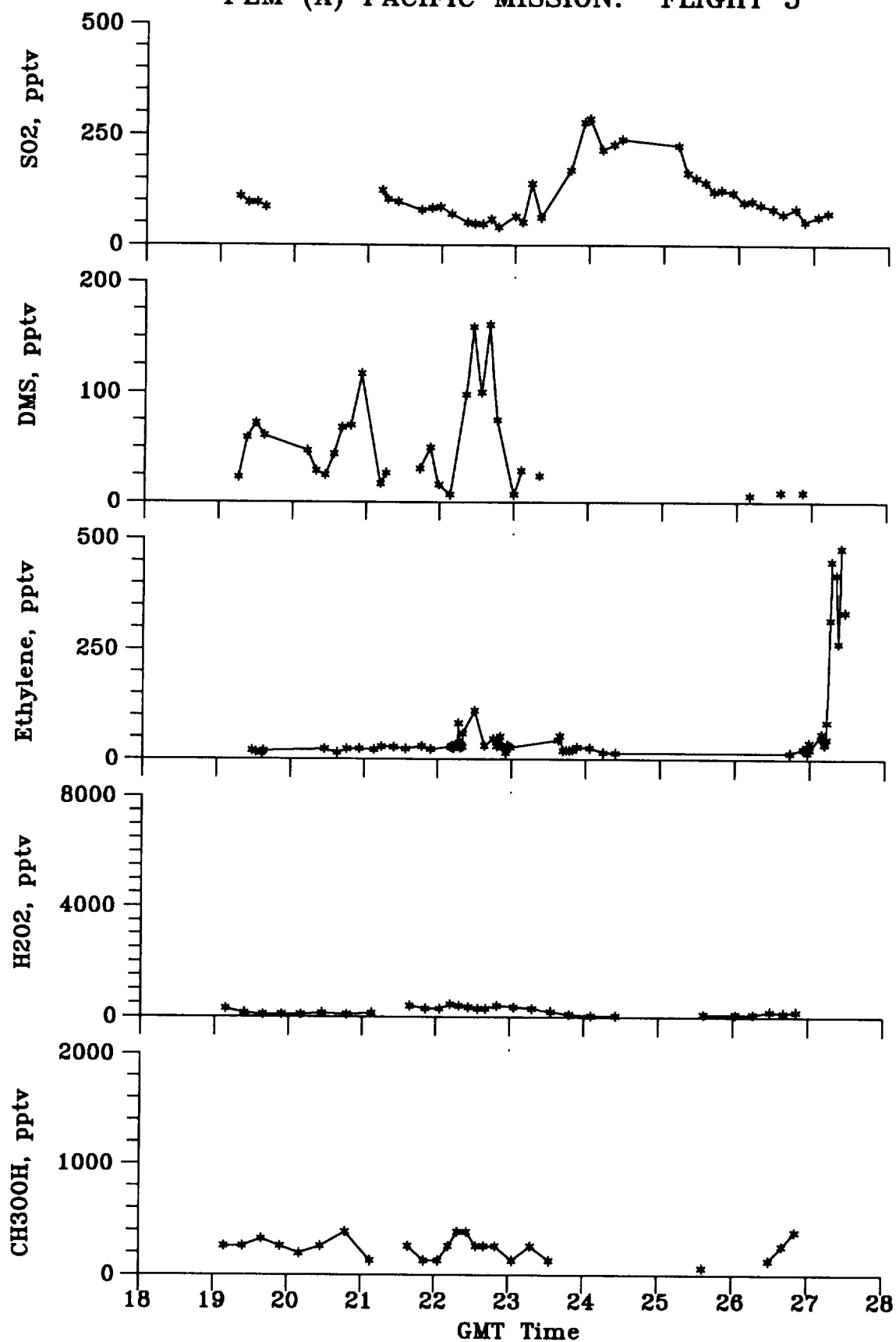
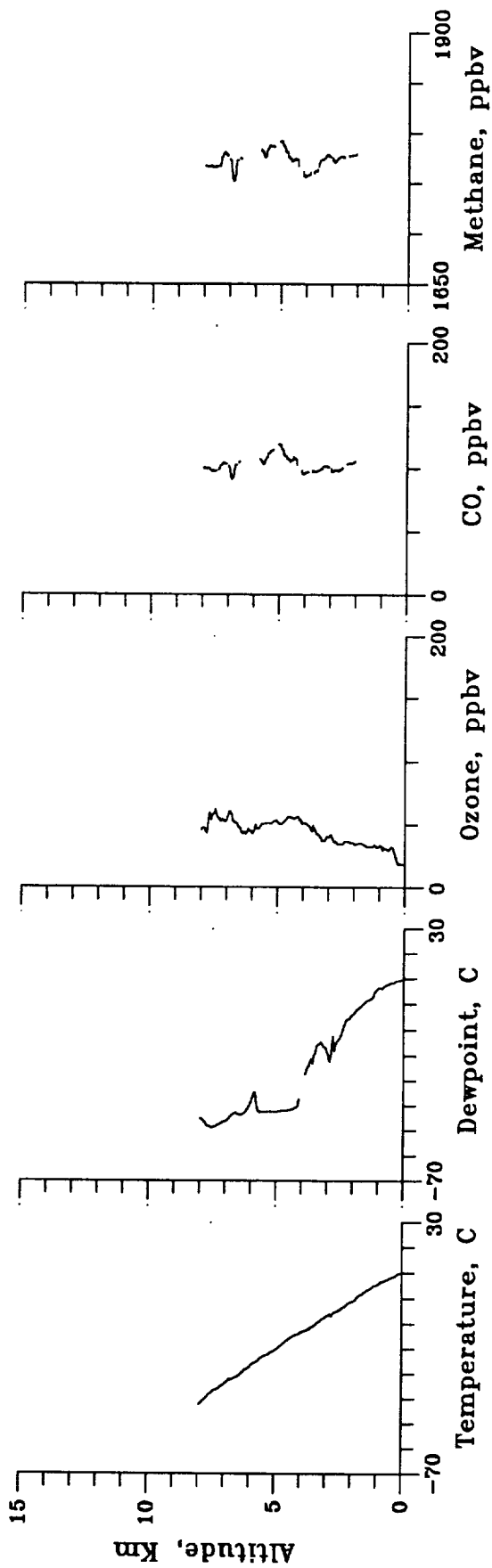


Figure A5.5

PEM (A) PACIFIC MISSION: FLIGHT 5 PROFILE AT 1900 GMT



PEM (A) PACIFIC MISSION: FLIGHT 5 PROFILE AT 2215 GMT

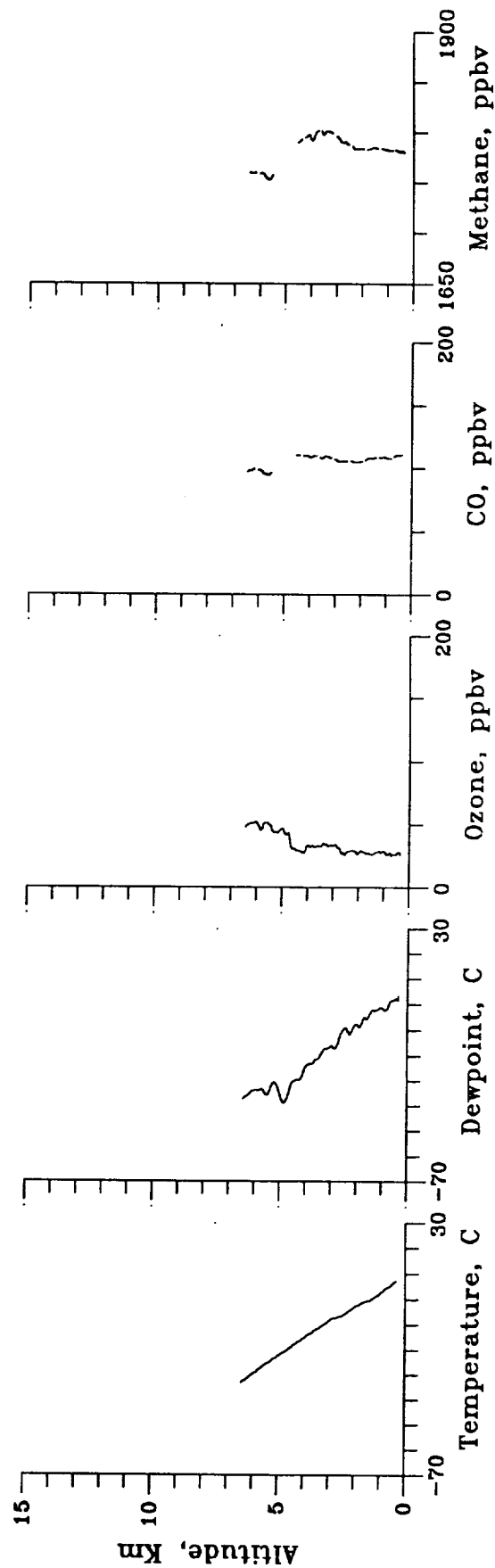


Figure A5.6

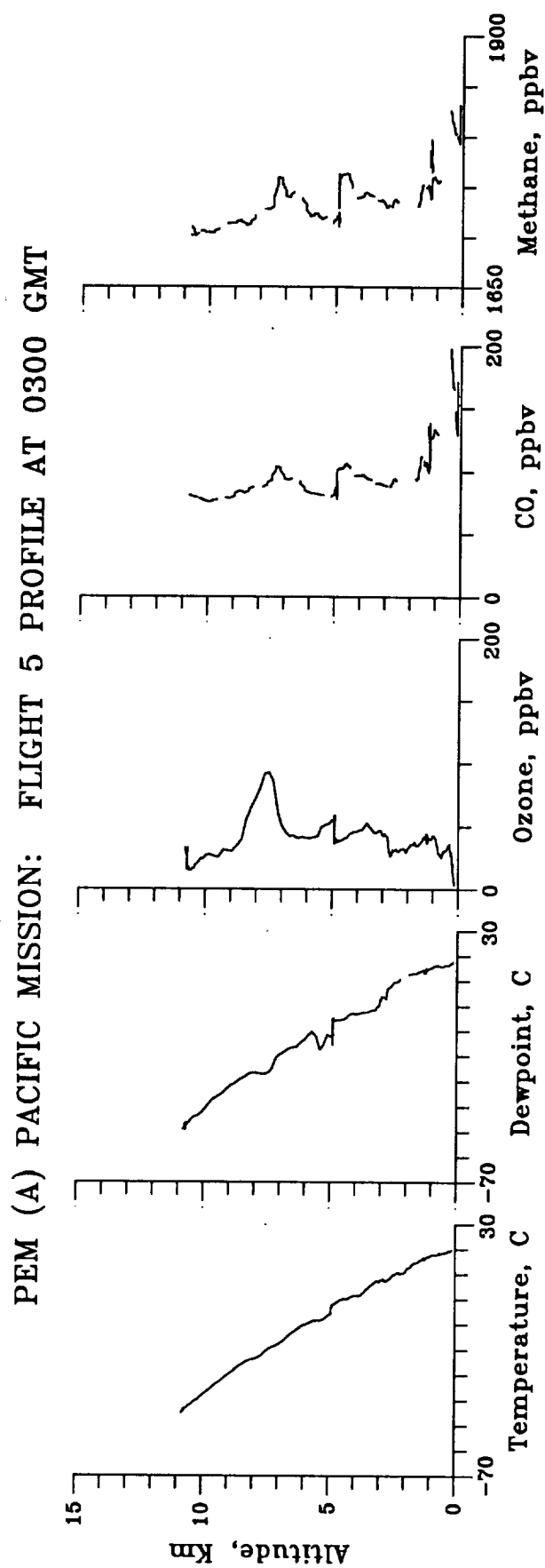


Figure A5.7





# PEM (A) PACIFIC MISSION: FLIGHT 6

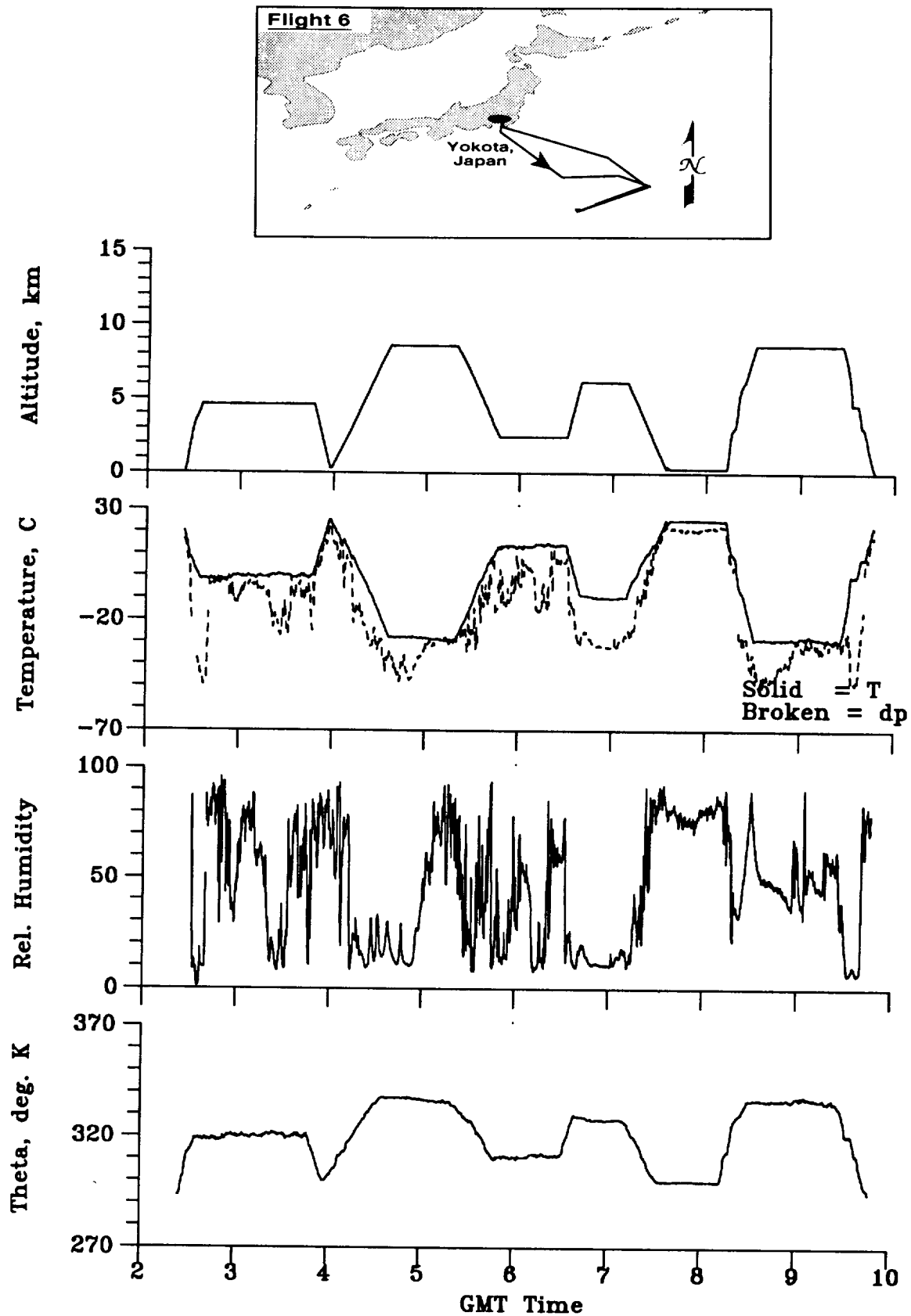


Figure A6.1

# PEM (A) PACIFIC MISSION: FLIGHT 6

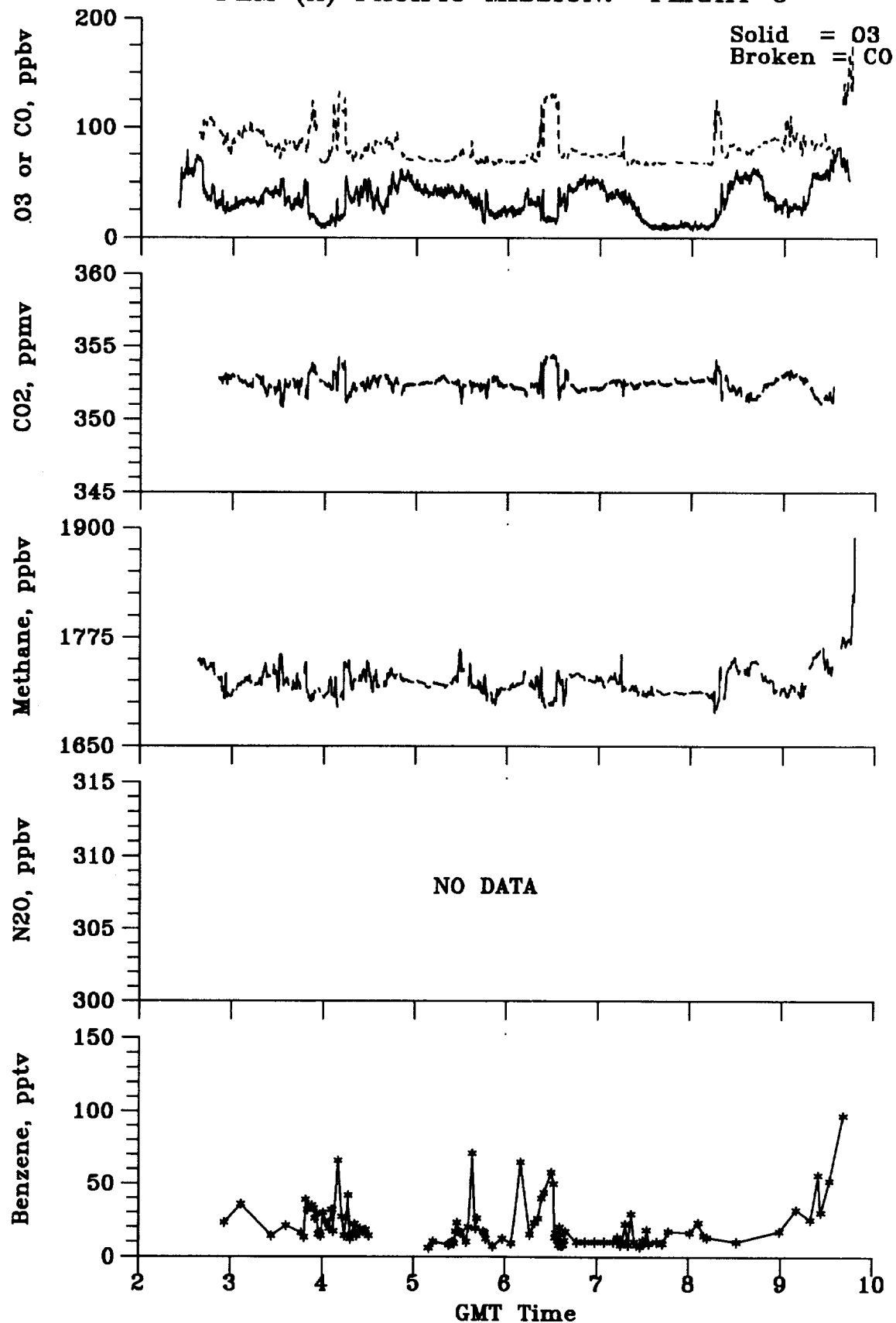


Figure A6.2

# PEM (A) PACIFIC MISSION: FLIGHT 6

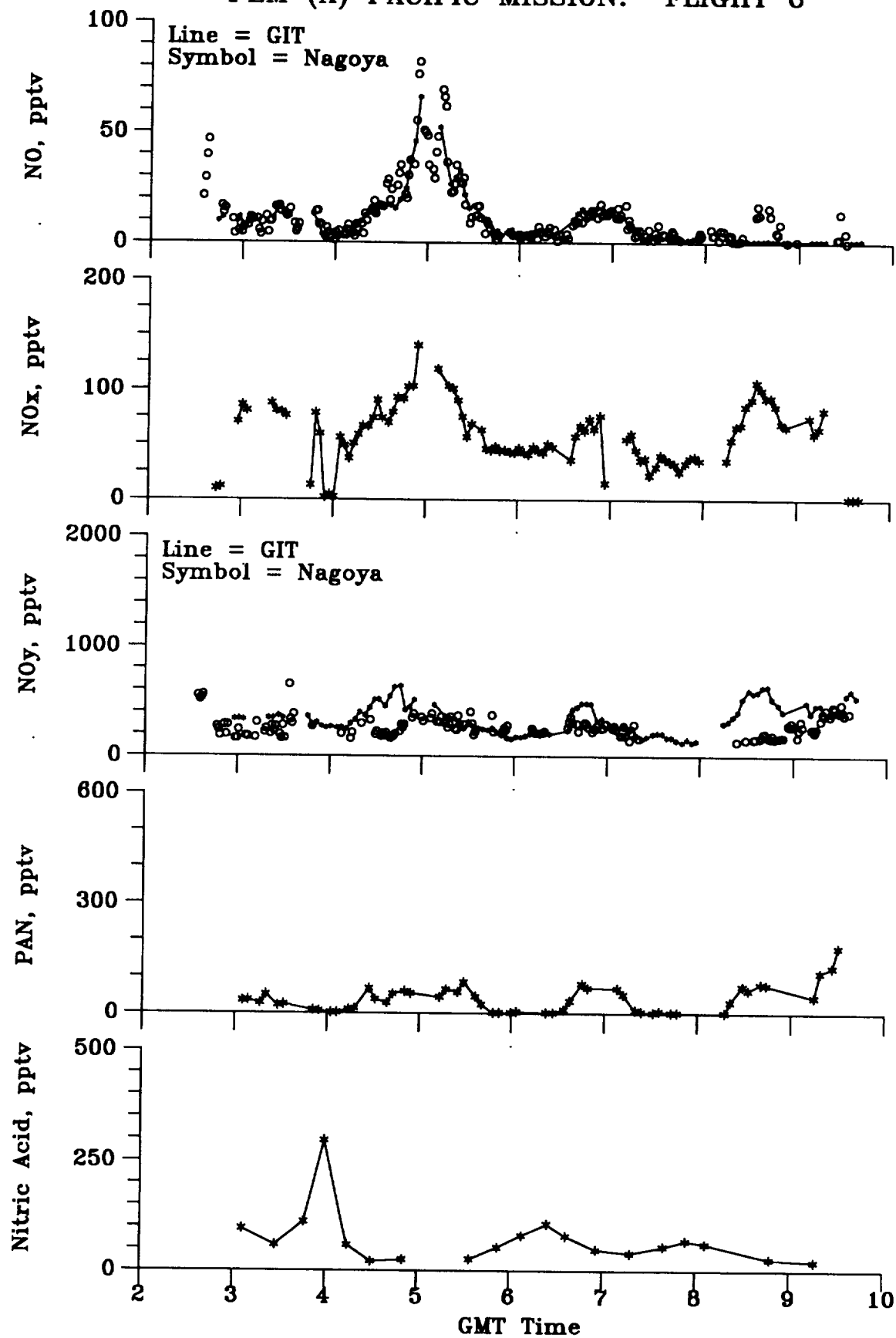


Figure A6.3

# PEM (A) PACIFIC MISSION: FLIGHT 6

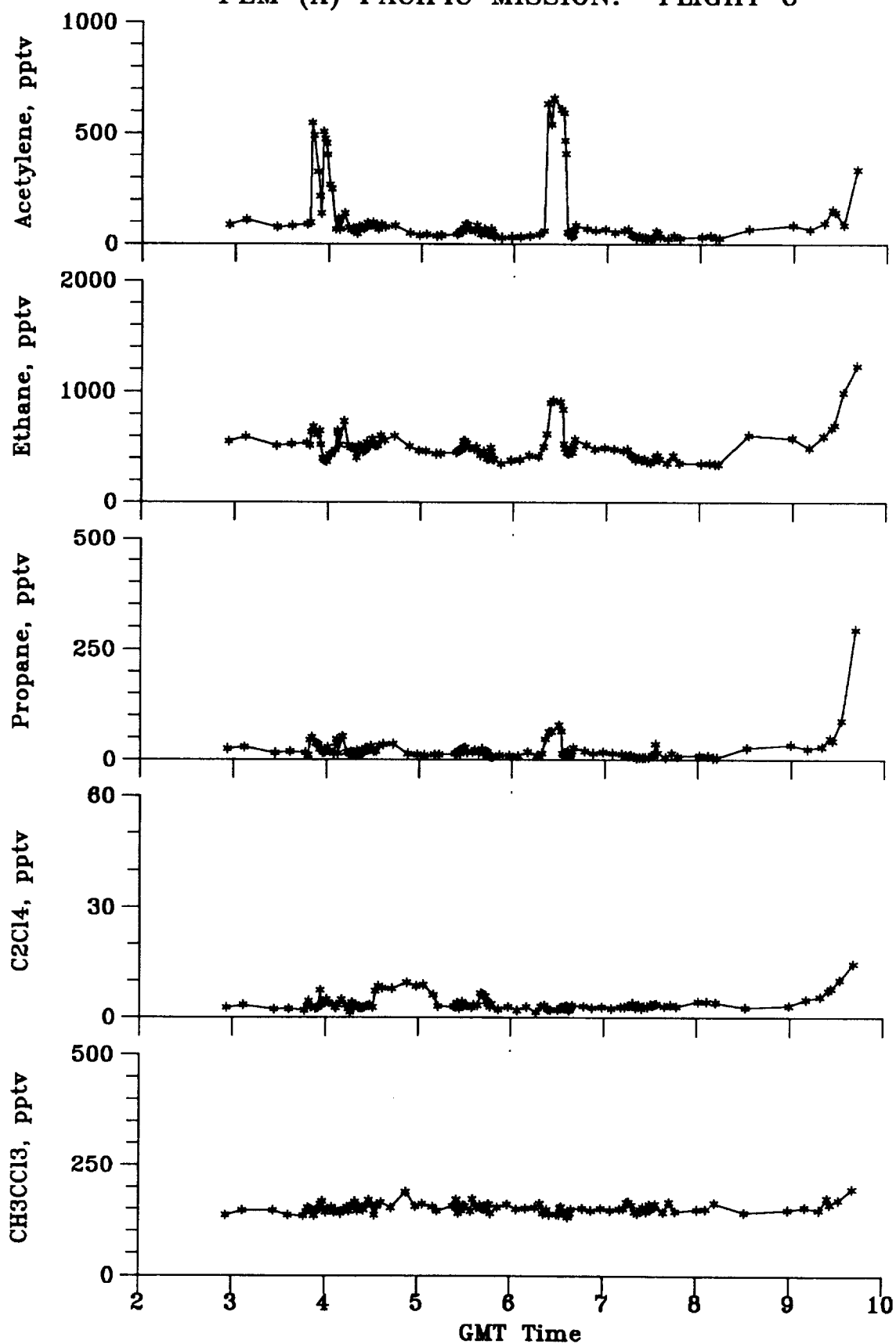


Figure A6.4

# PEM (A) PACIFIC MISSION: FLIGHT 6

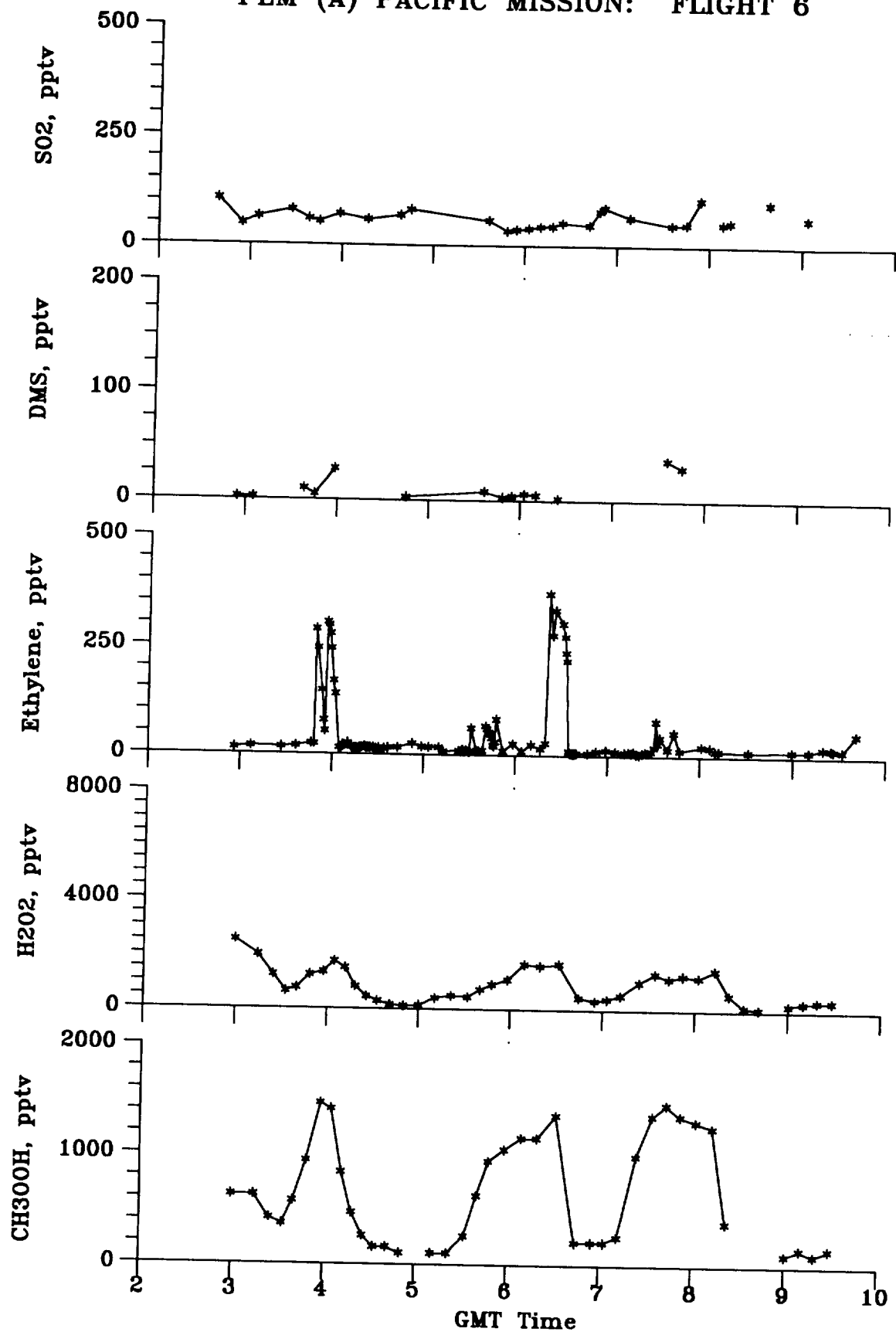


Figure A6.5

PEM (A) PACIFIC MISSION: FLIGHT 6 PROFILE AT 0415 GMT

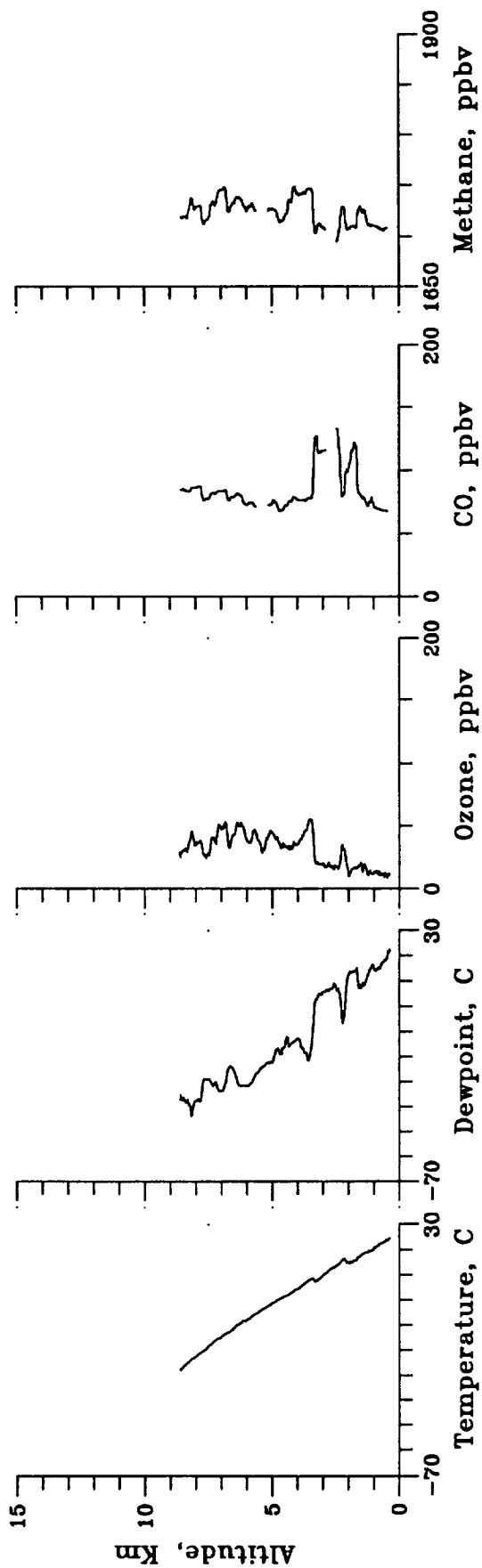
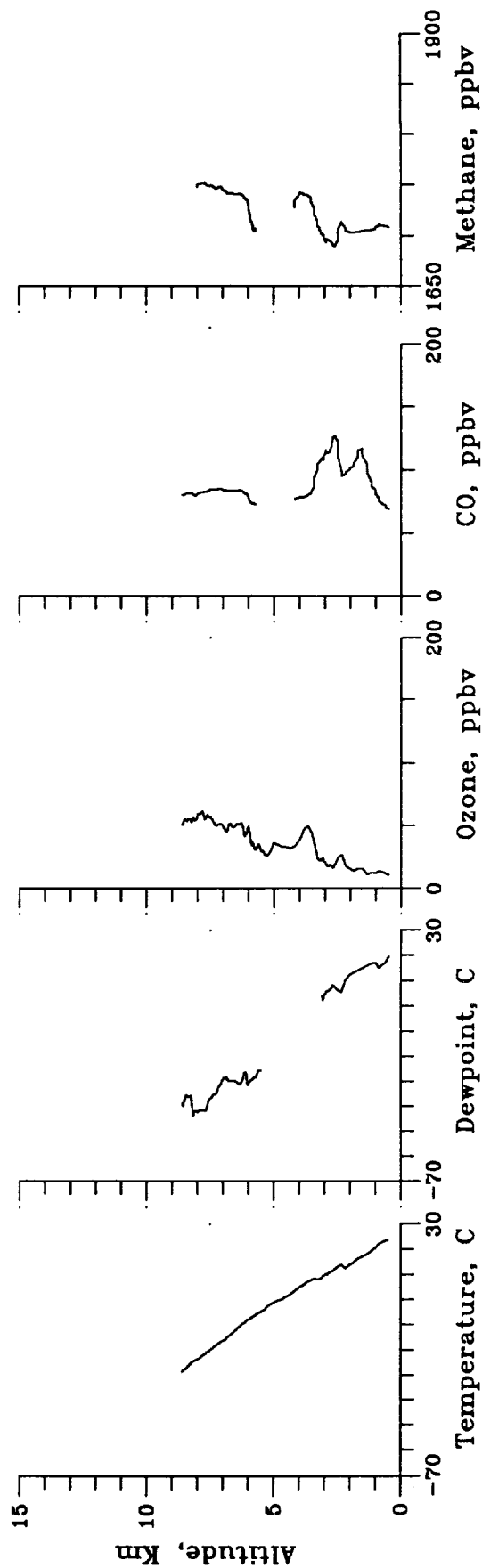


Figure A6.6

PEM (A) PACIFIC MISSION: FLIGHT 6 PROFILE AT 0830 GMT



# PEM (A) PACIFIC MISSION: FLIGHT 7

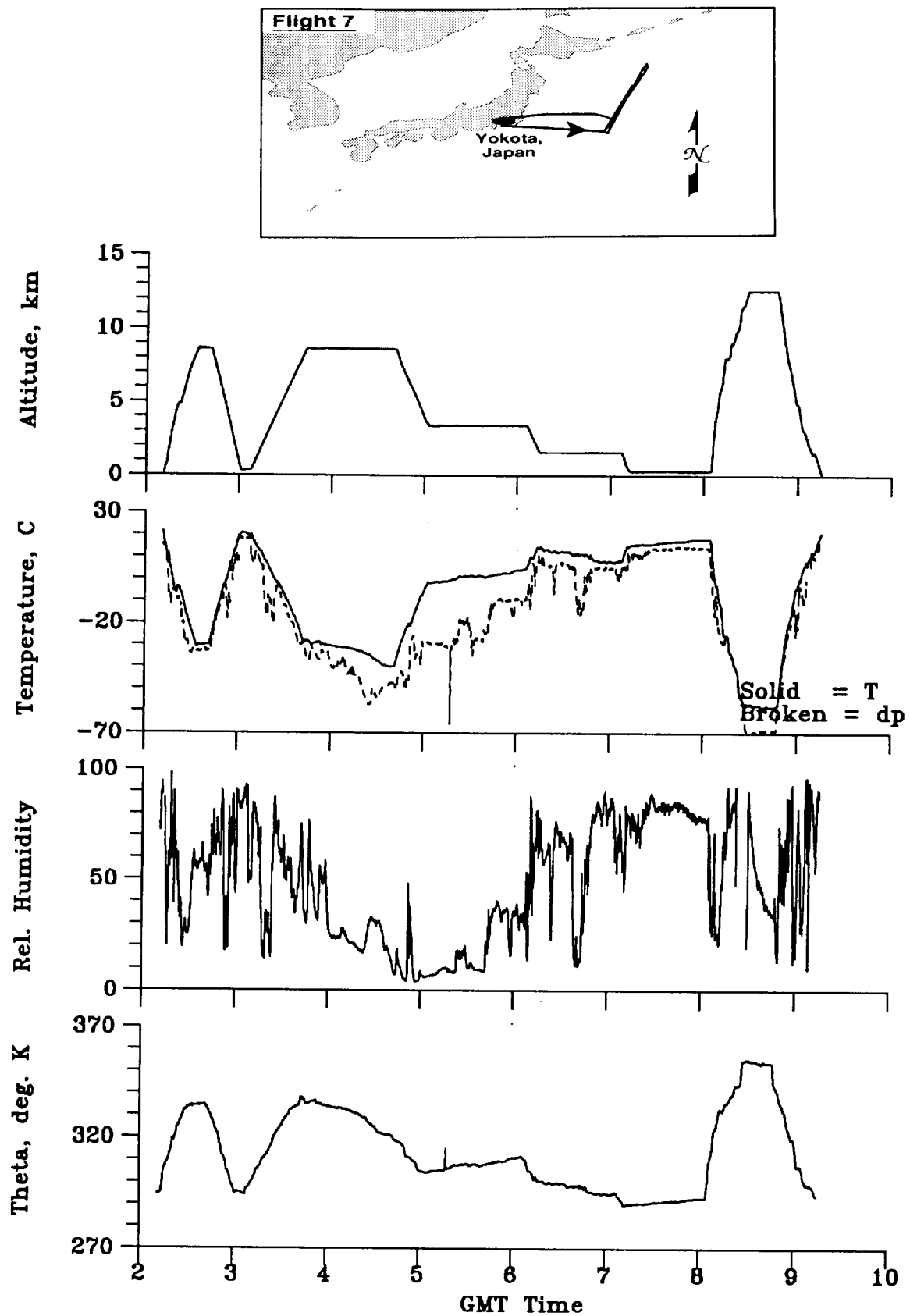


Figure A7.1

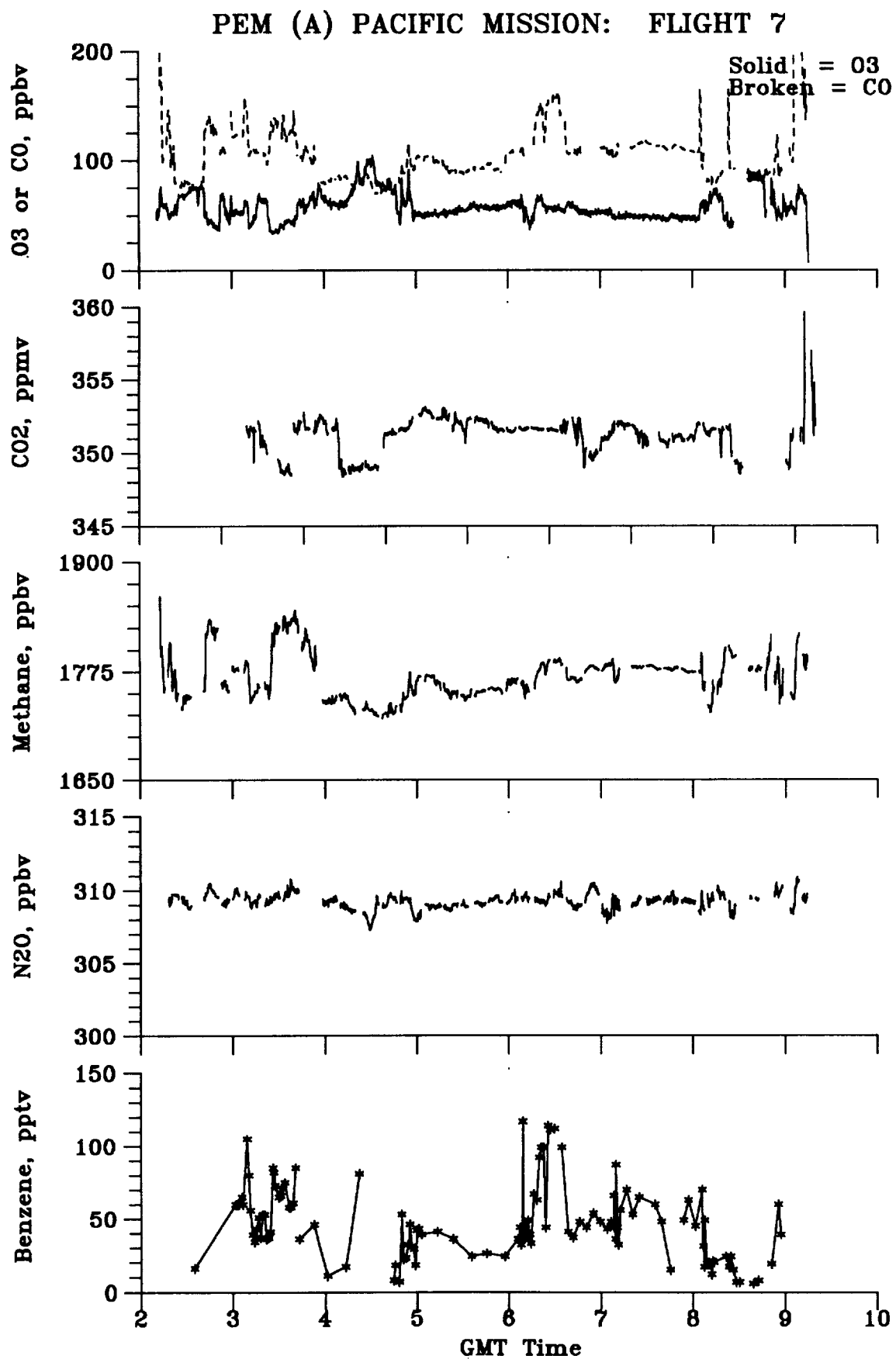


Figure A7.2



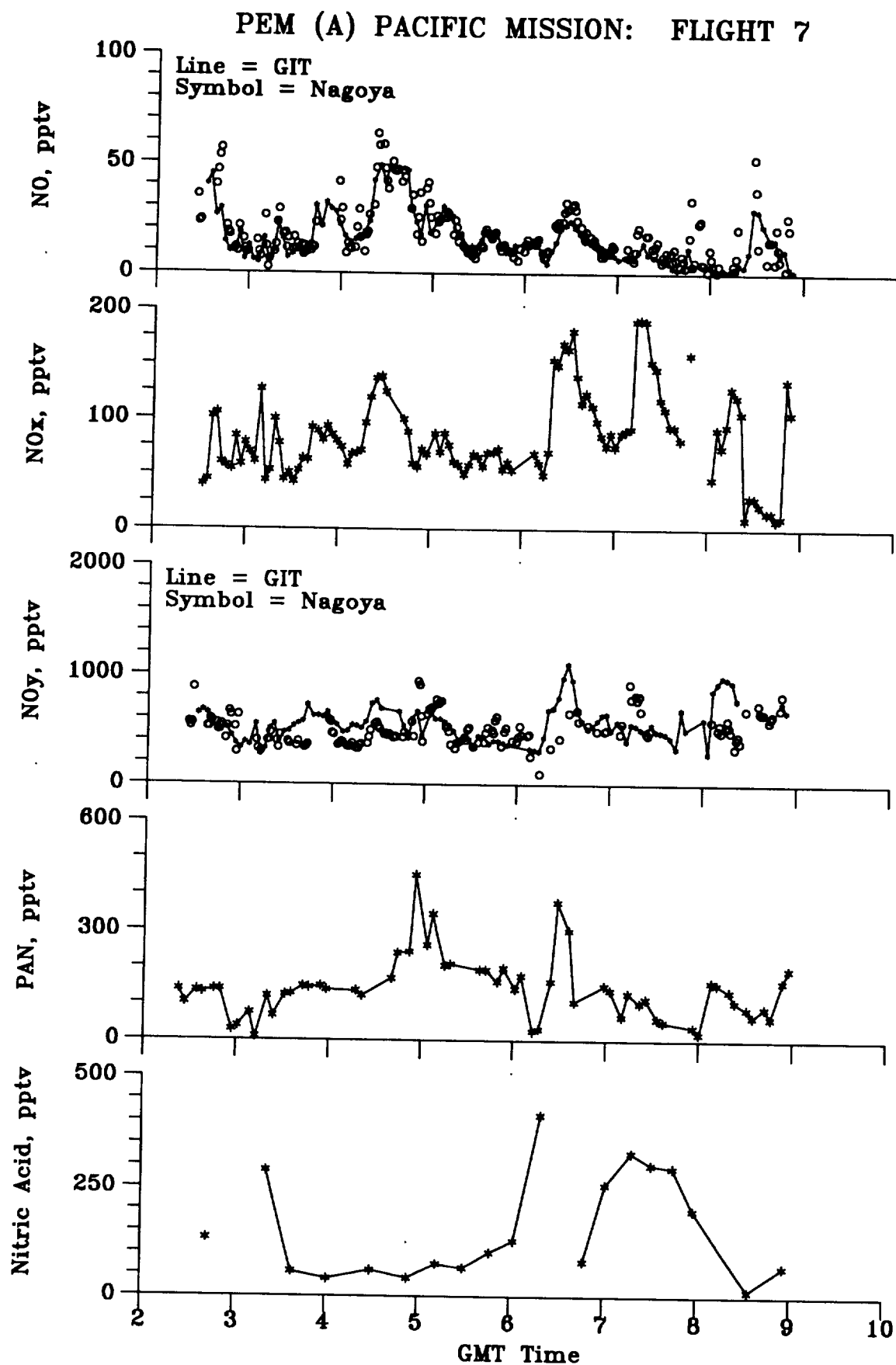


Figure A7.3

# PEM (A) PACIFIC MISSION: FLIGHT 7

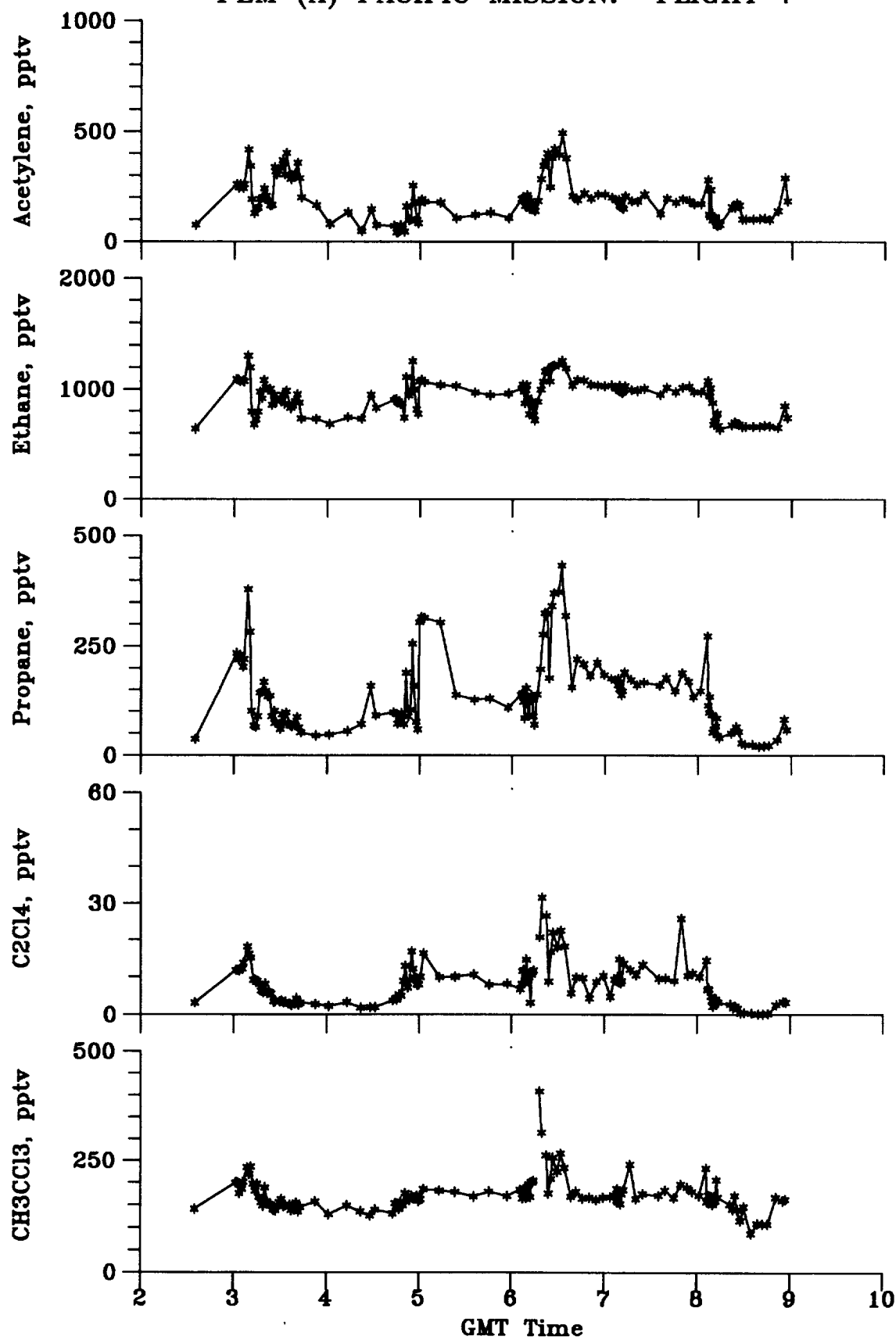


Figure A7.4

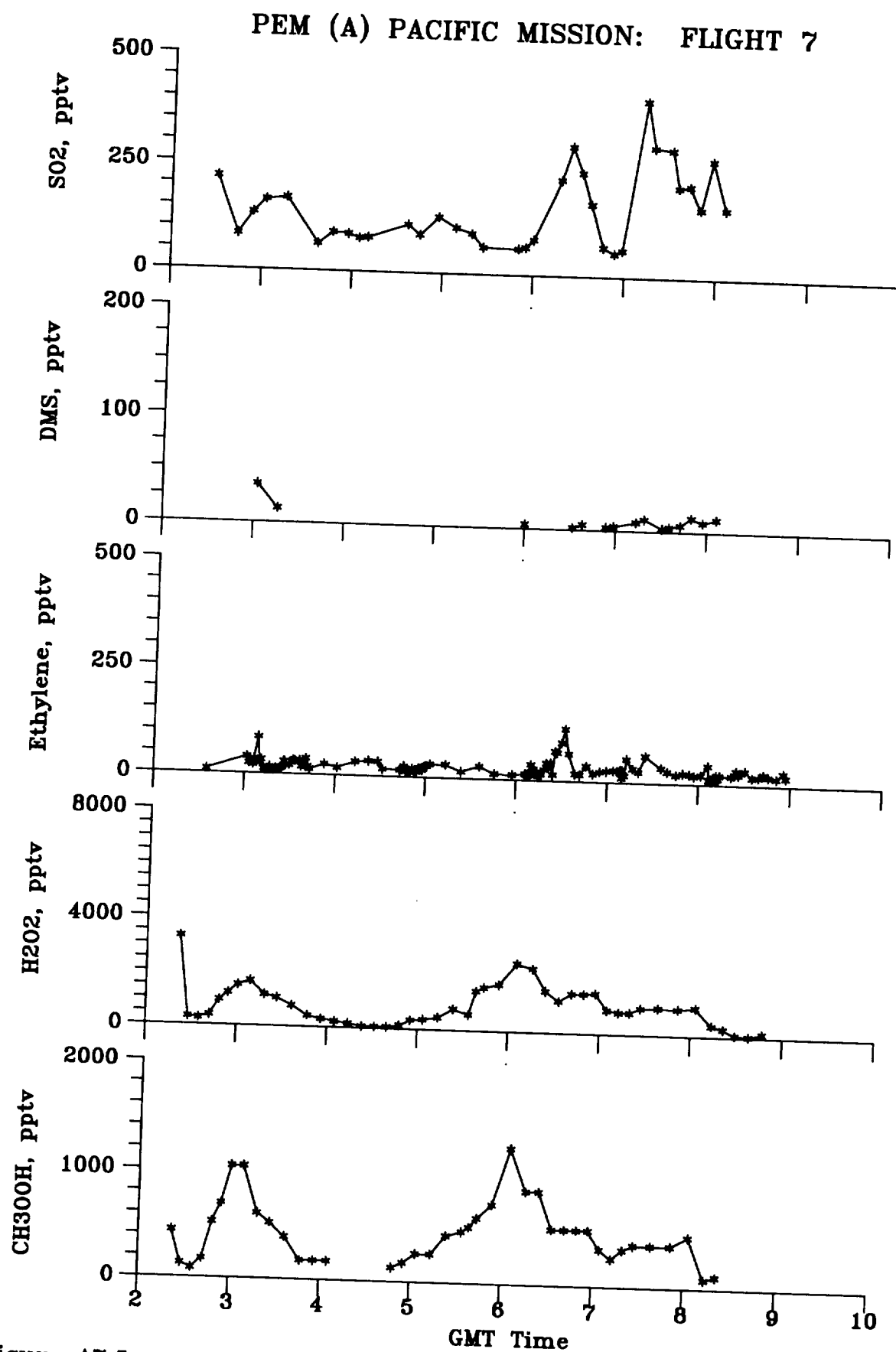
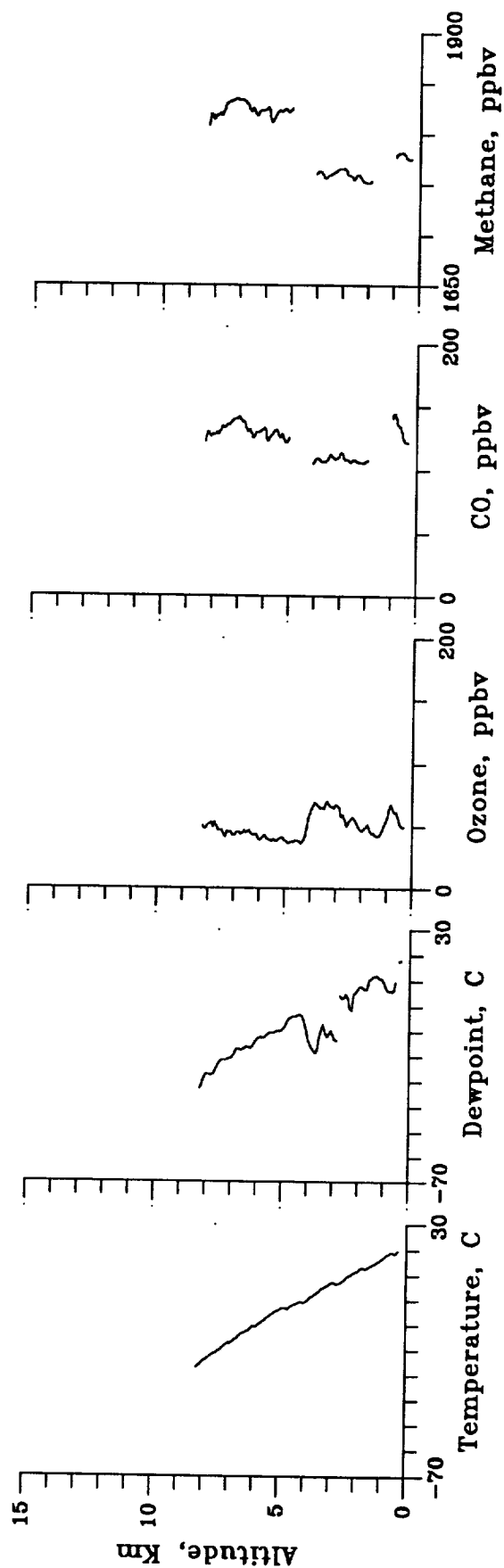


Figure A7.5

PEM (A) PACIFIC MISSION: FLIGHT 7 PROFILE AT 0300 GMT



PEM (A) PACIFIC MISSION: FLIGHT 7 PROFILE AT 0815 GMT

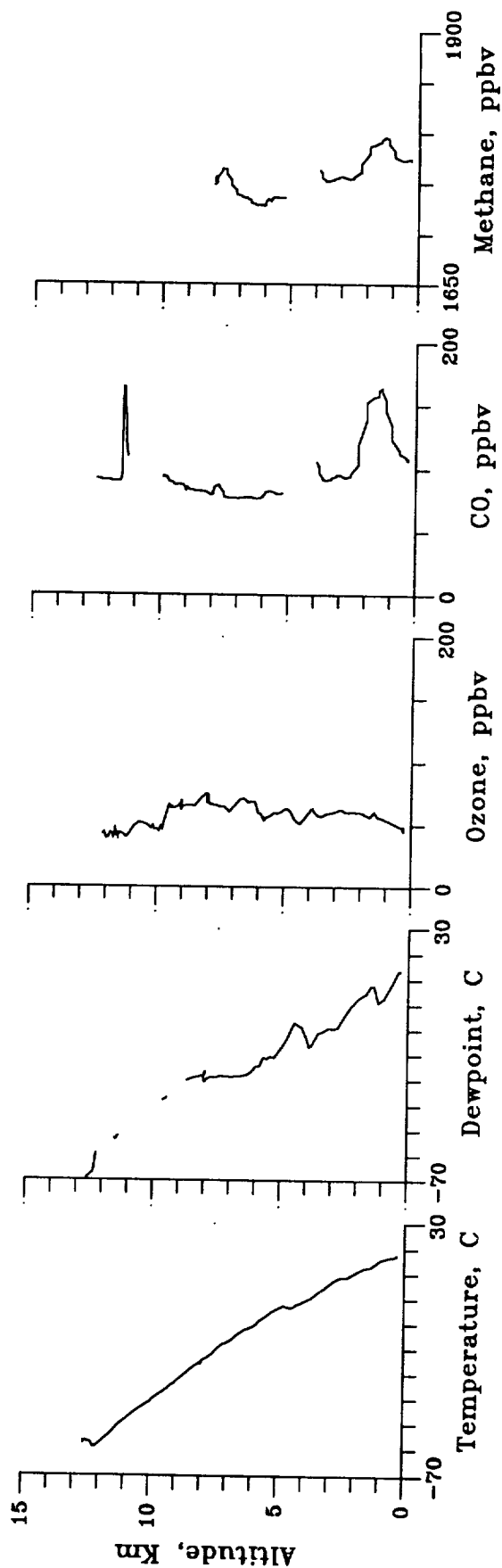


Figure A7.6

# PEM (A) PACIFIC MISSION: FLIGHT 8

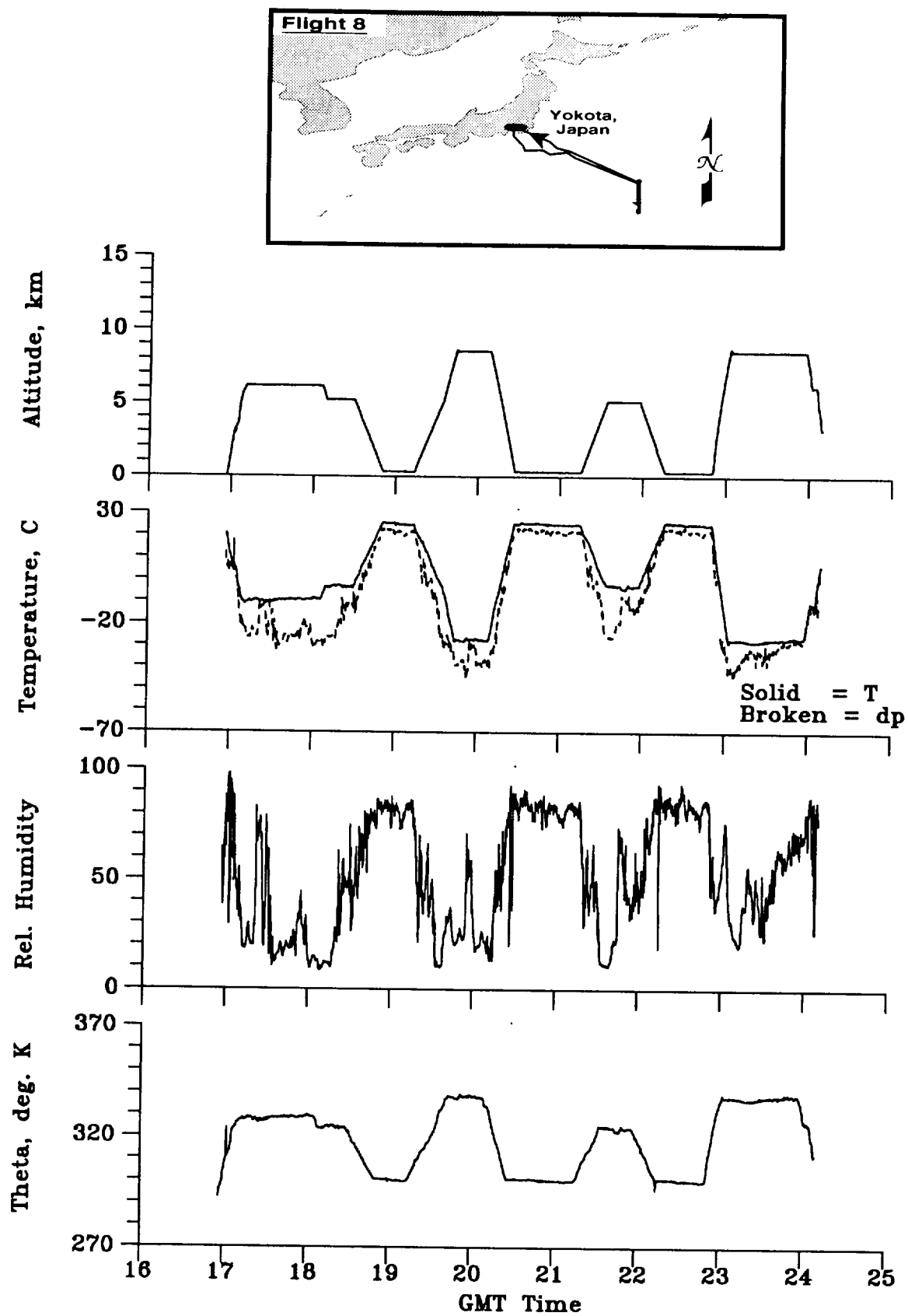


Figure A8.1

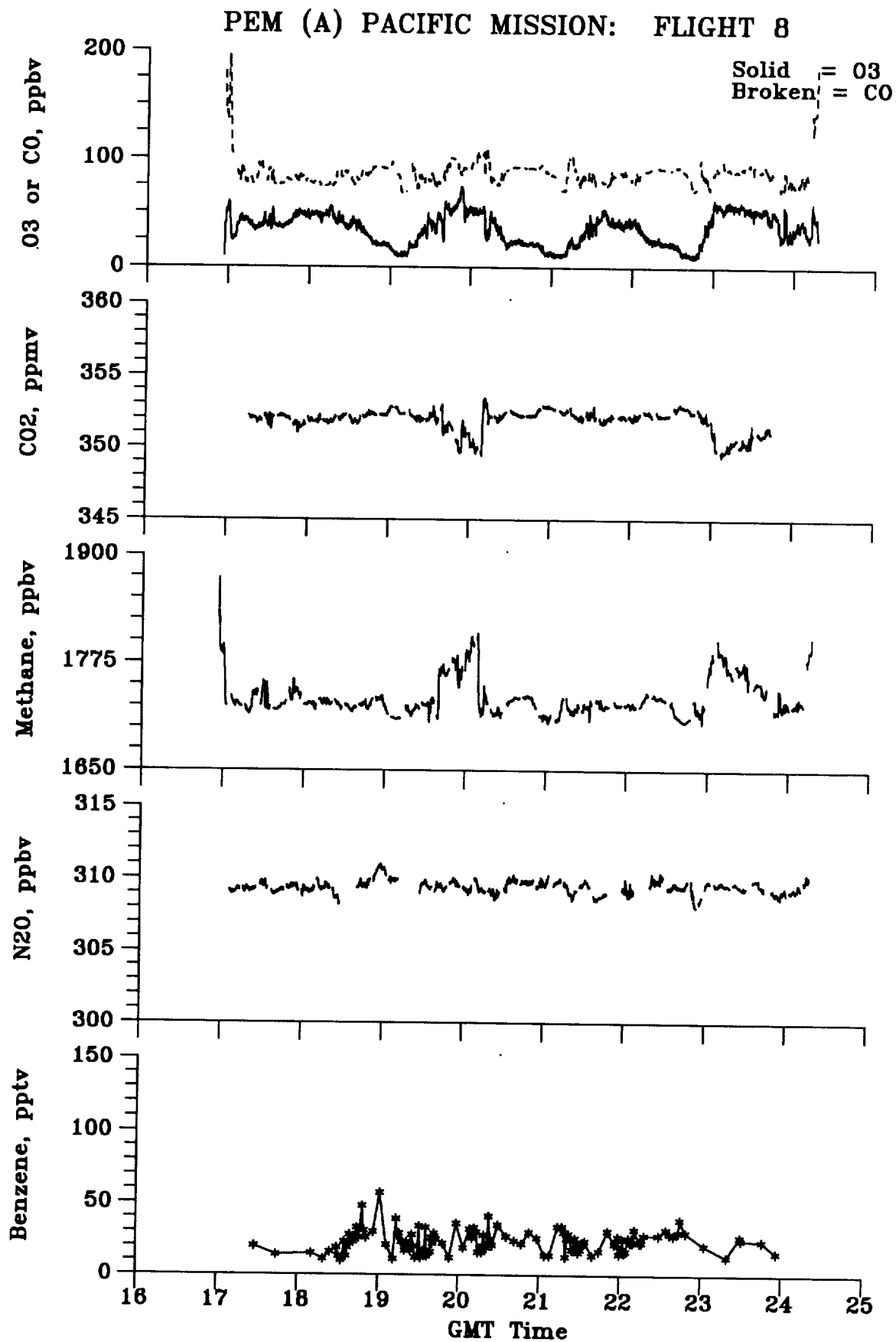


Figure A8.2

# PEM (A) PACIFIC MISSION: FLIGHT 8

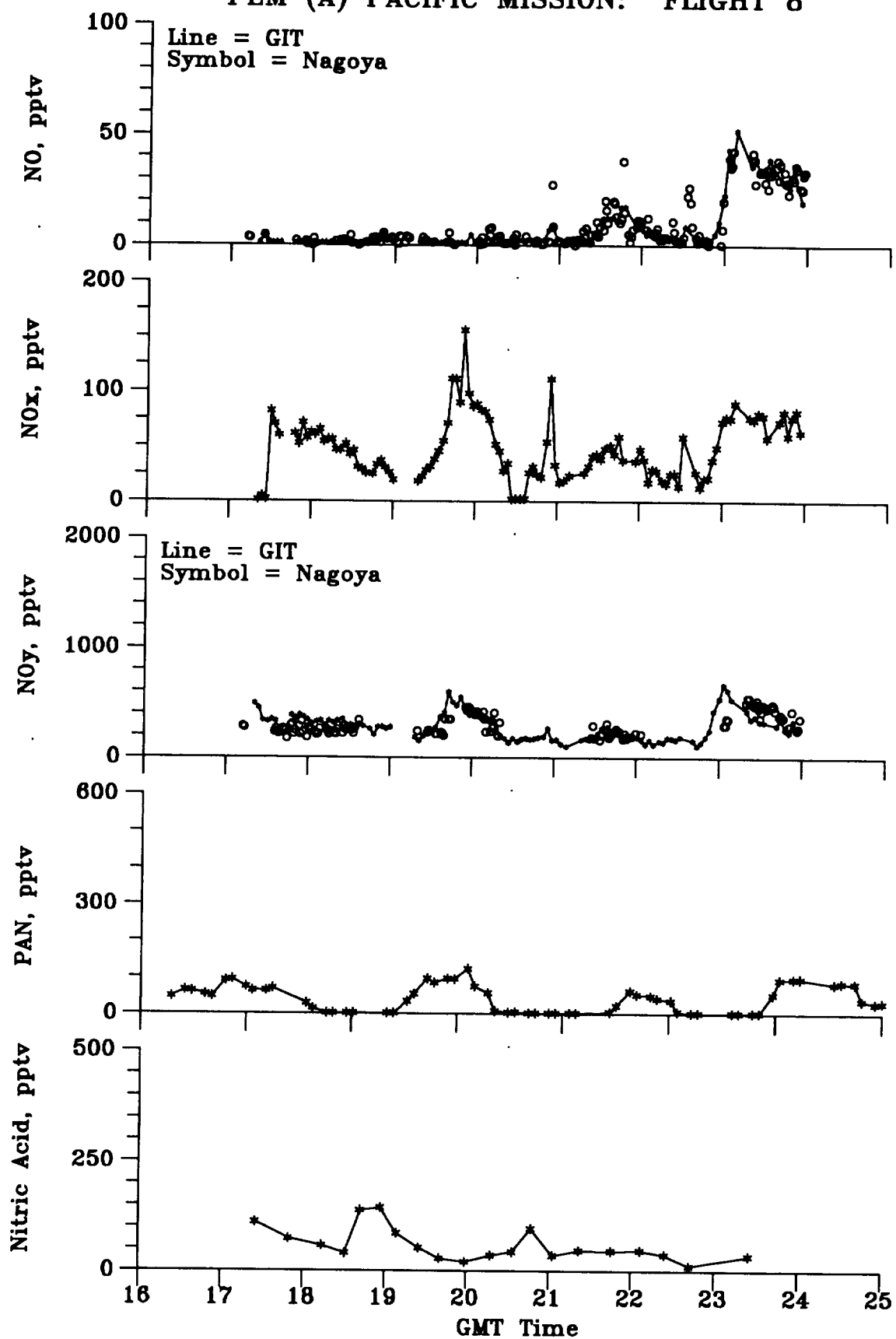


Figure A8.3

PEM (A) PACIFIC MISSION: FLIGHT 8

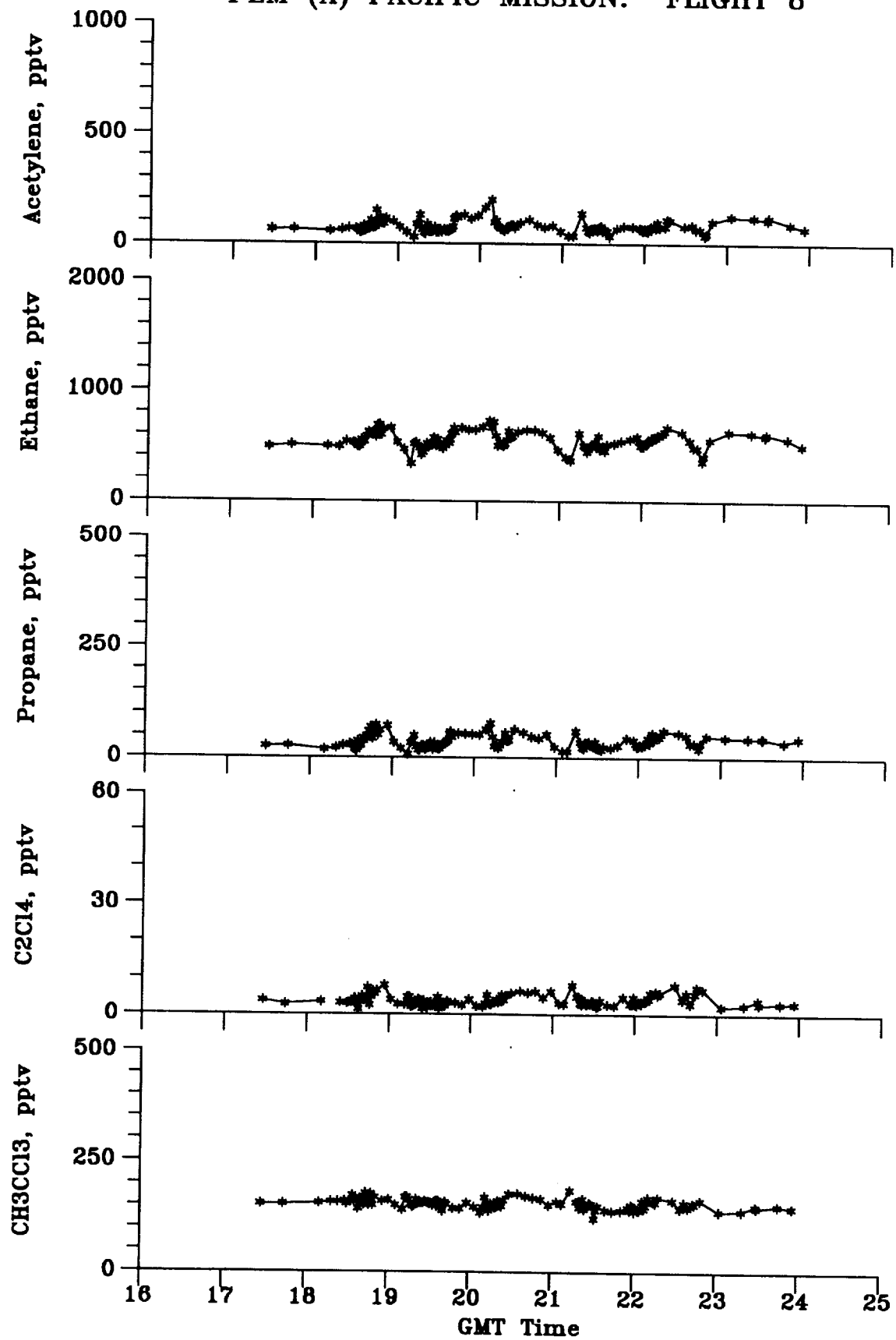


Figure A8.4



# PEM (A) PACIFIC MISSION: FLIGHT 8

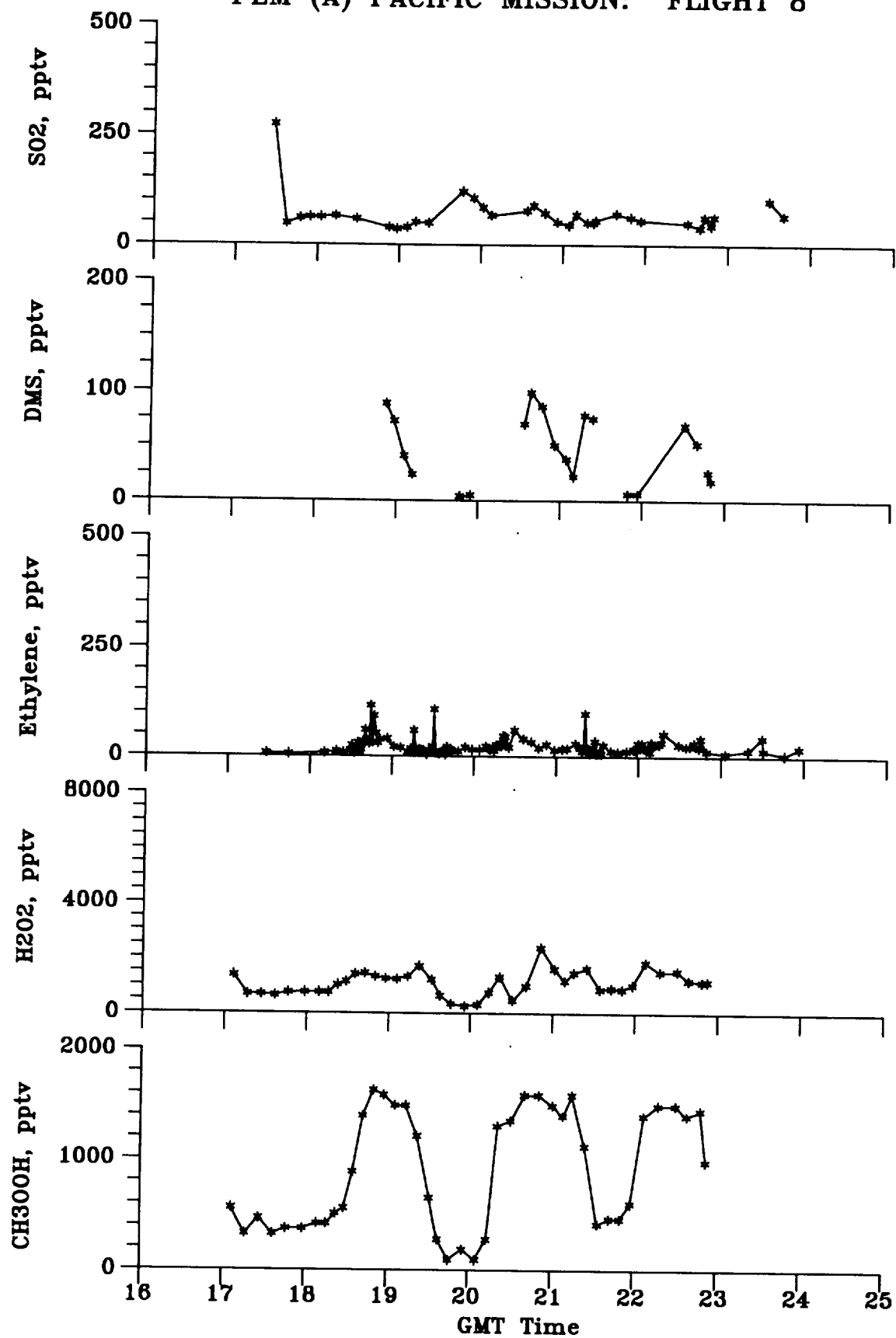


Figure A8.5

PEM (A) PACIFIC MISSION: FLIGHT 8 PROFILE AT 1930 GMT

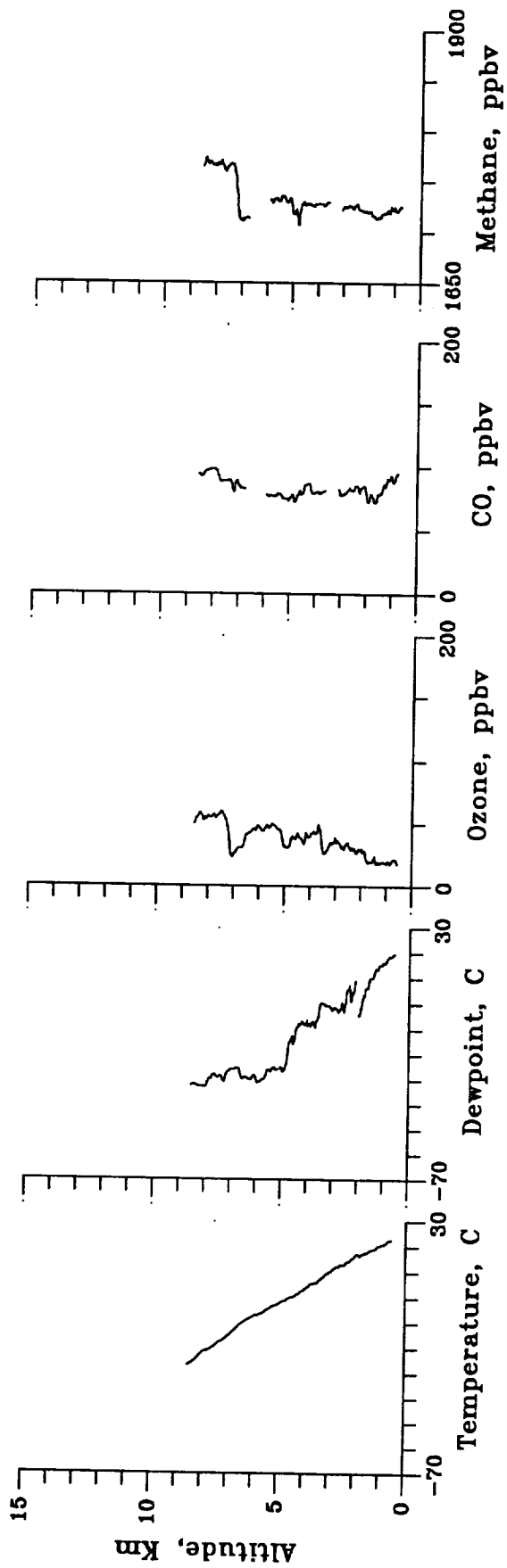
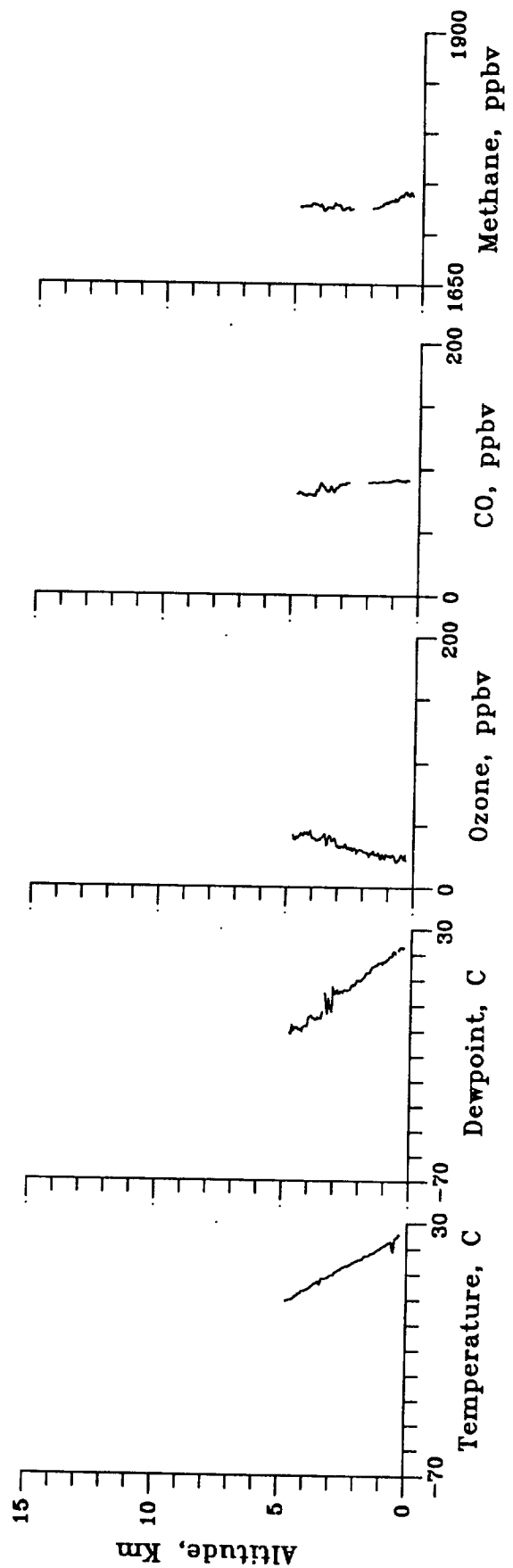


Figure A8.6

PEM (A) PACIFIC MISSION: FLIGHT 8 PROFILE AT 2200 GMT



# PEM (A) PACIFIC MISSION: FLIGHT 9

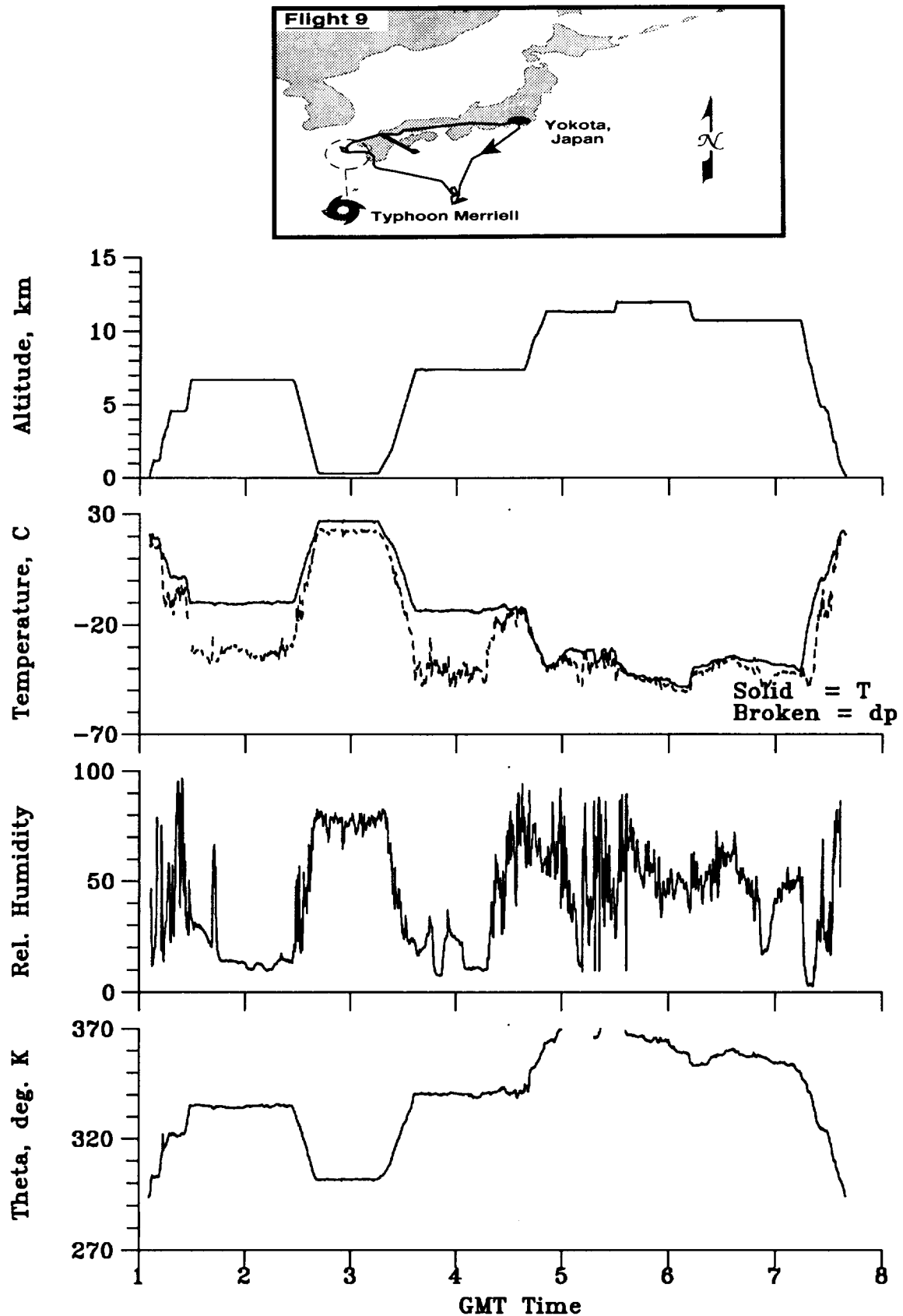


Figure A9.1

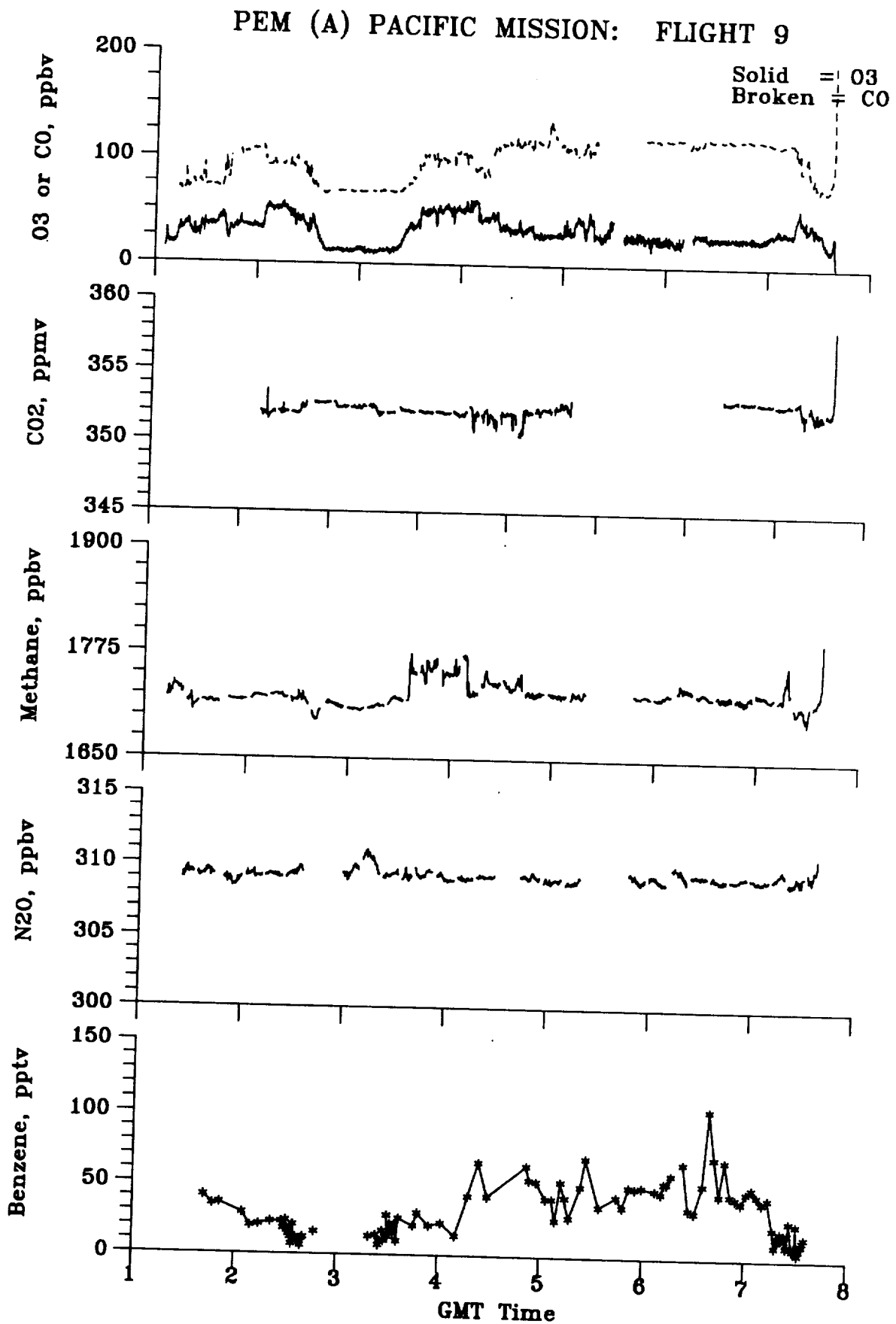


Figure A9.2

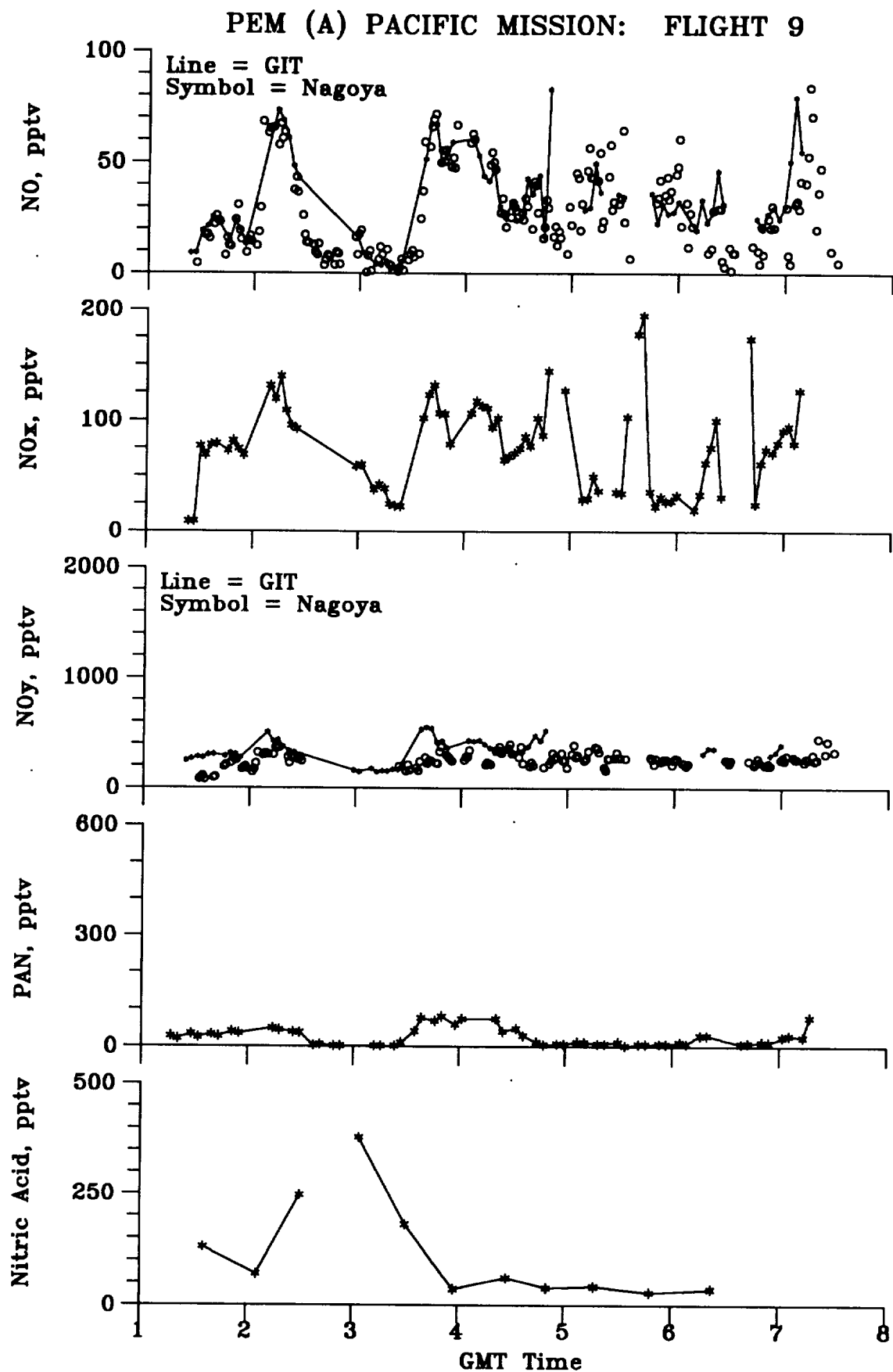


Figure A9.3

PEM (A) PACIFIC MISSION: FLIGHT 9

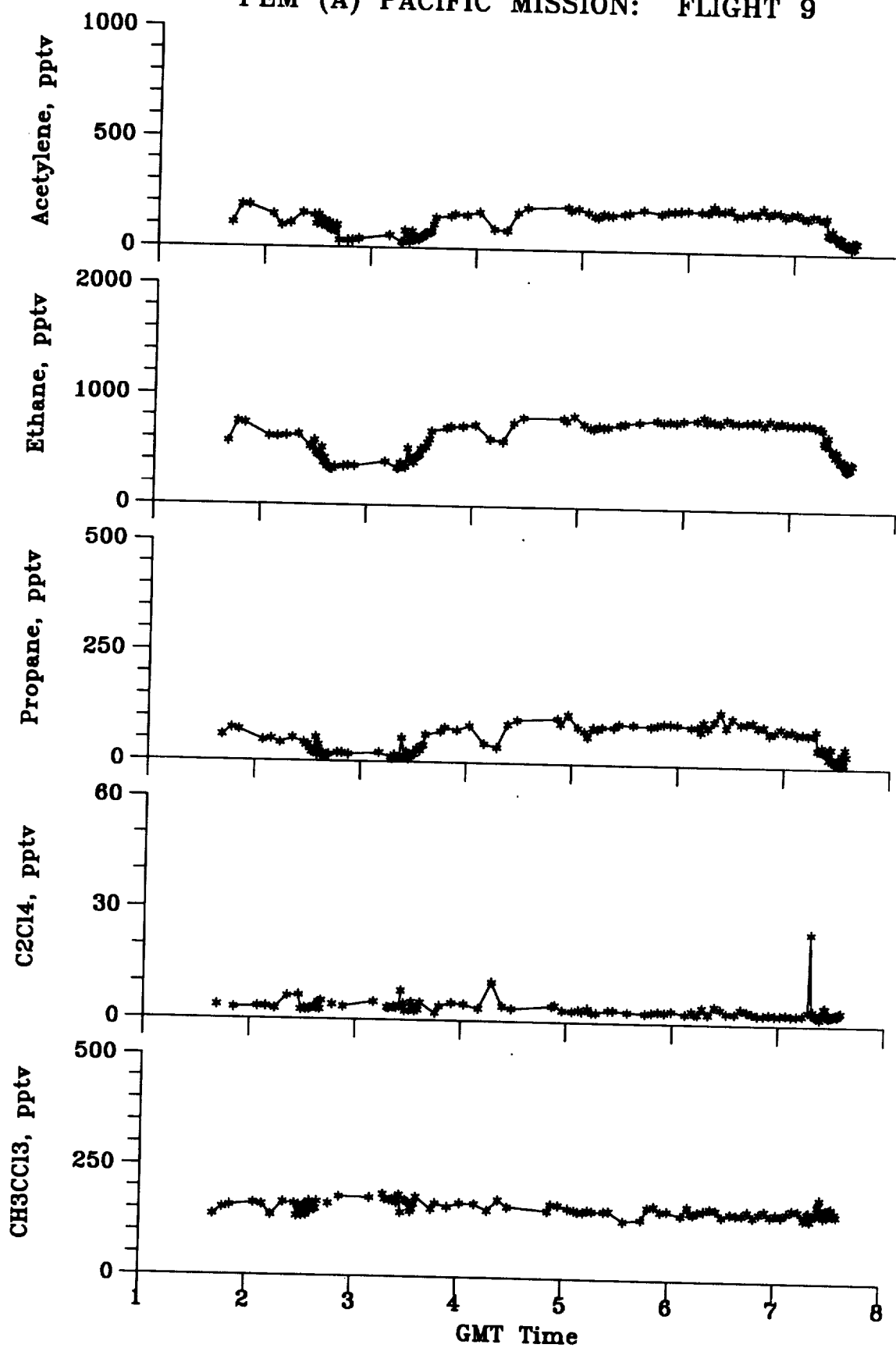


Figure A9.4

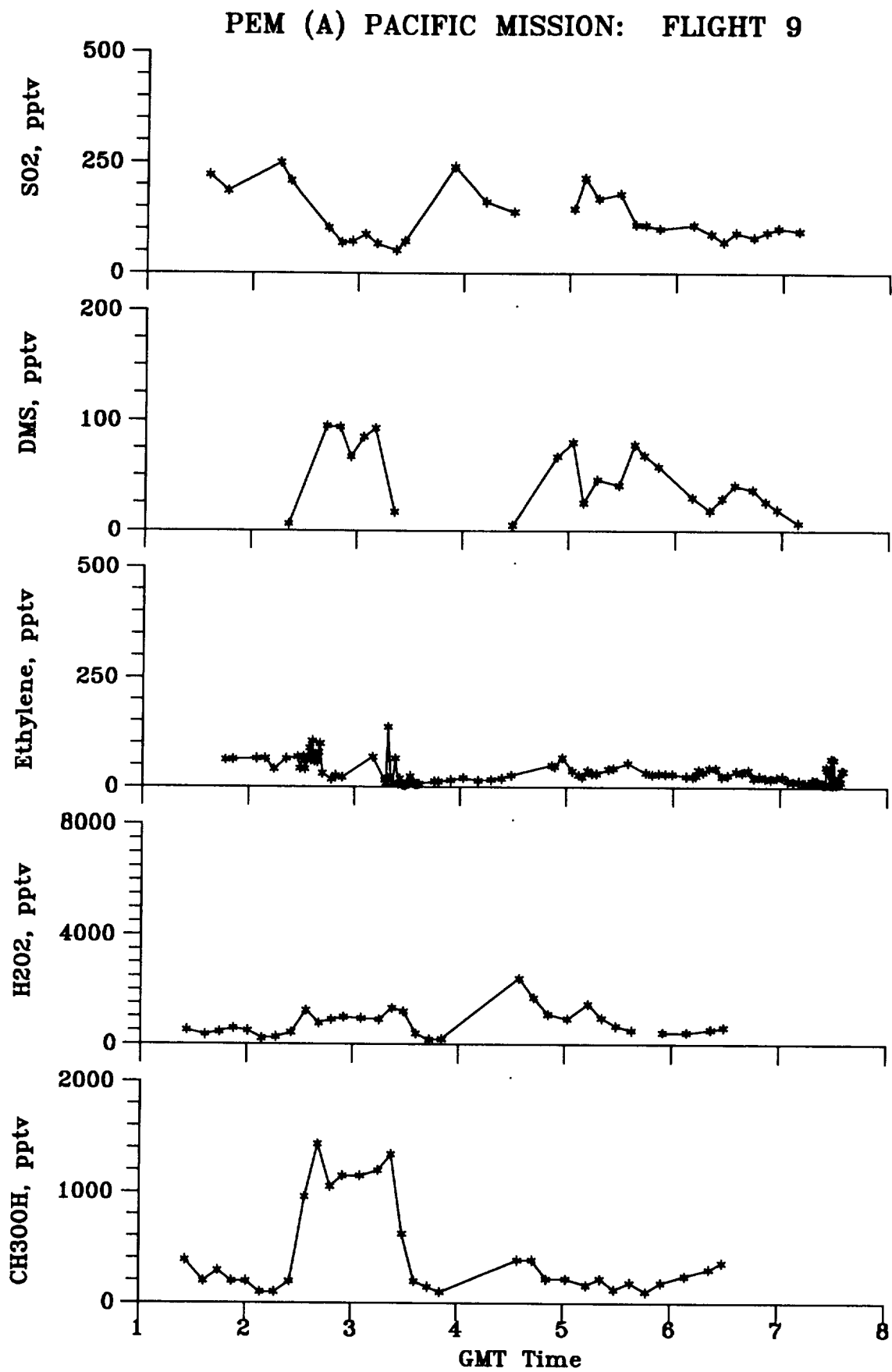
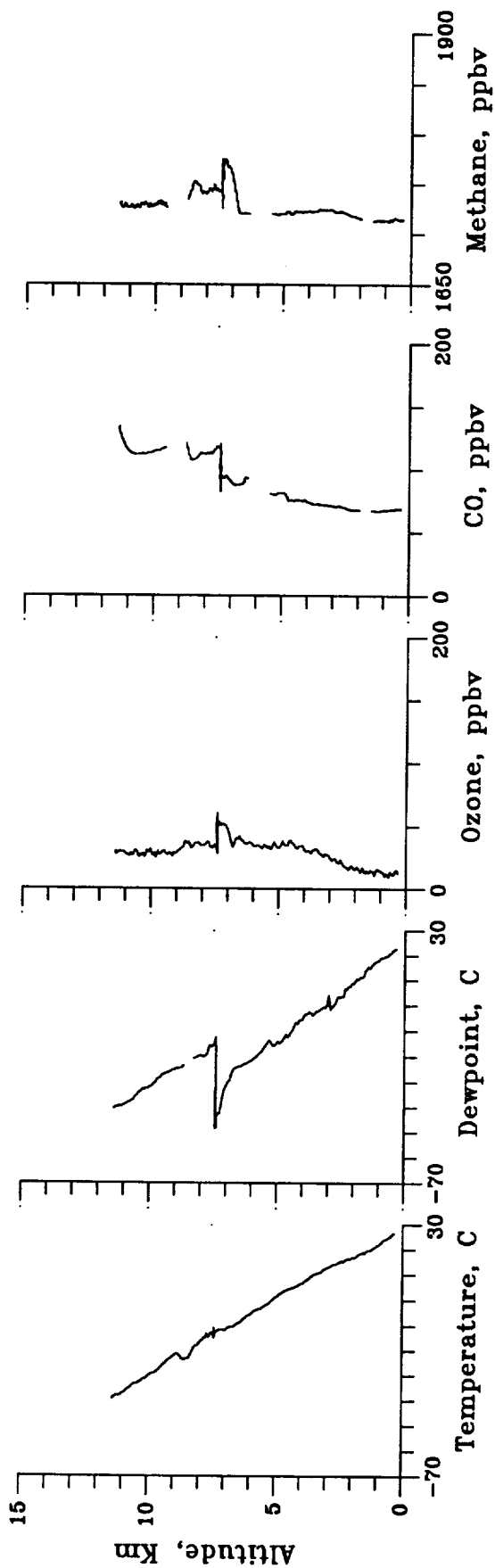


Figure A9.5

PEM (A) PACIFIC MISSION: FLIGHT 9 PROFILE AT 0400 GMT



PEM (A) PACIFIC MISSION: FLIGHT 9 PROFILE AT 0730 GMT

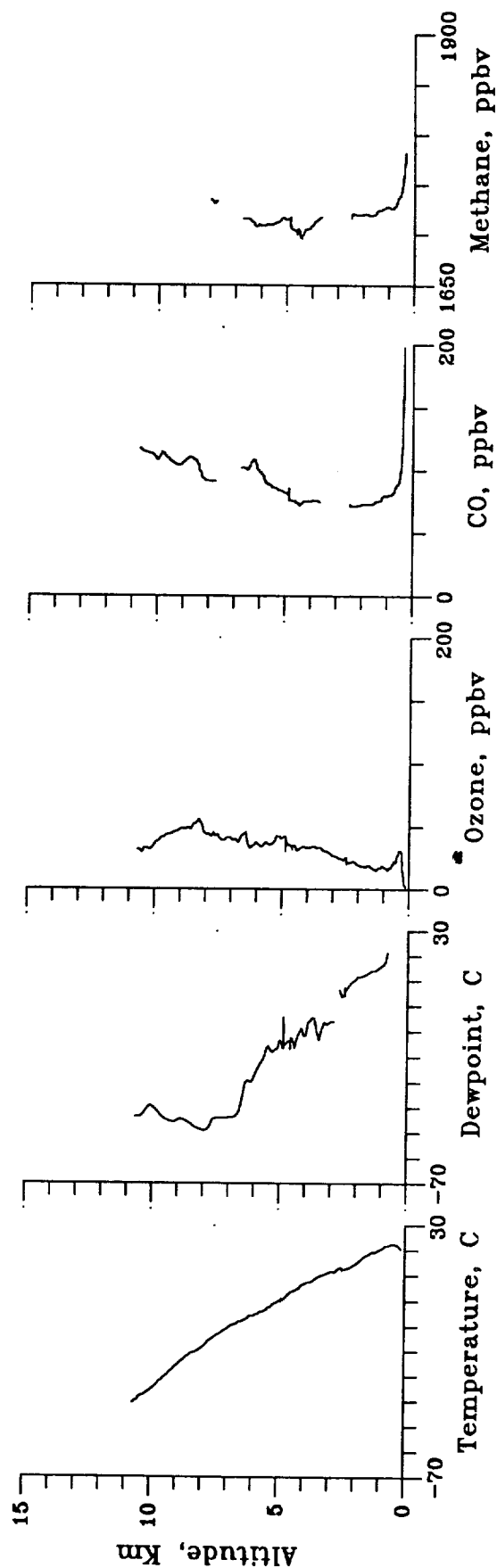


Figure A9.6



# PEM (A) PACIFIC MISSION: FLIGHT 10

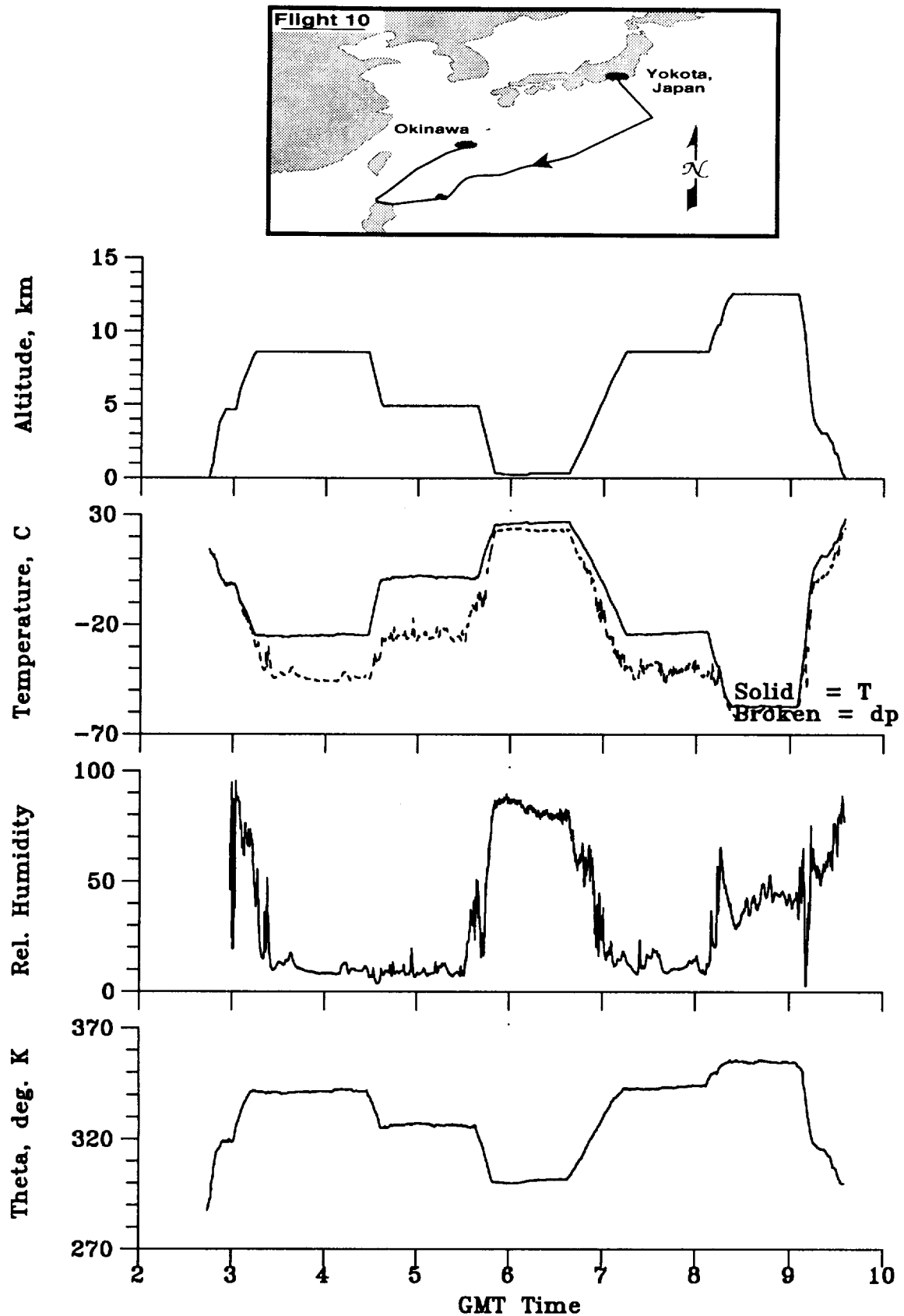


Figure A10.1

# PEM (A) PACIFIC MISSION: FLIGHT 10

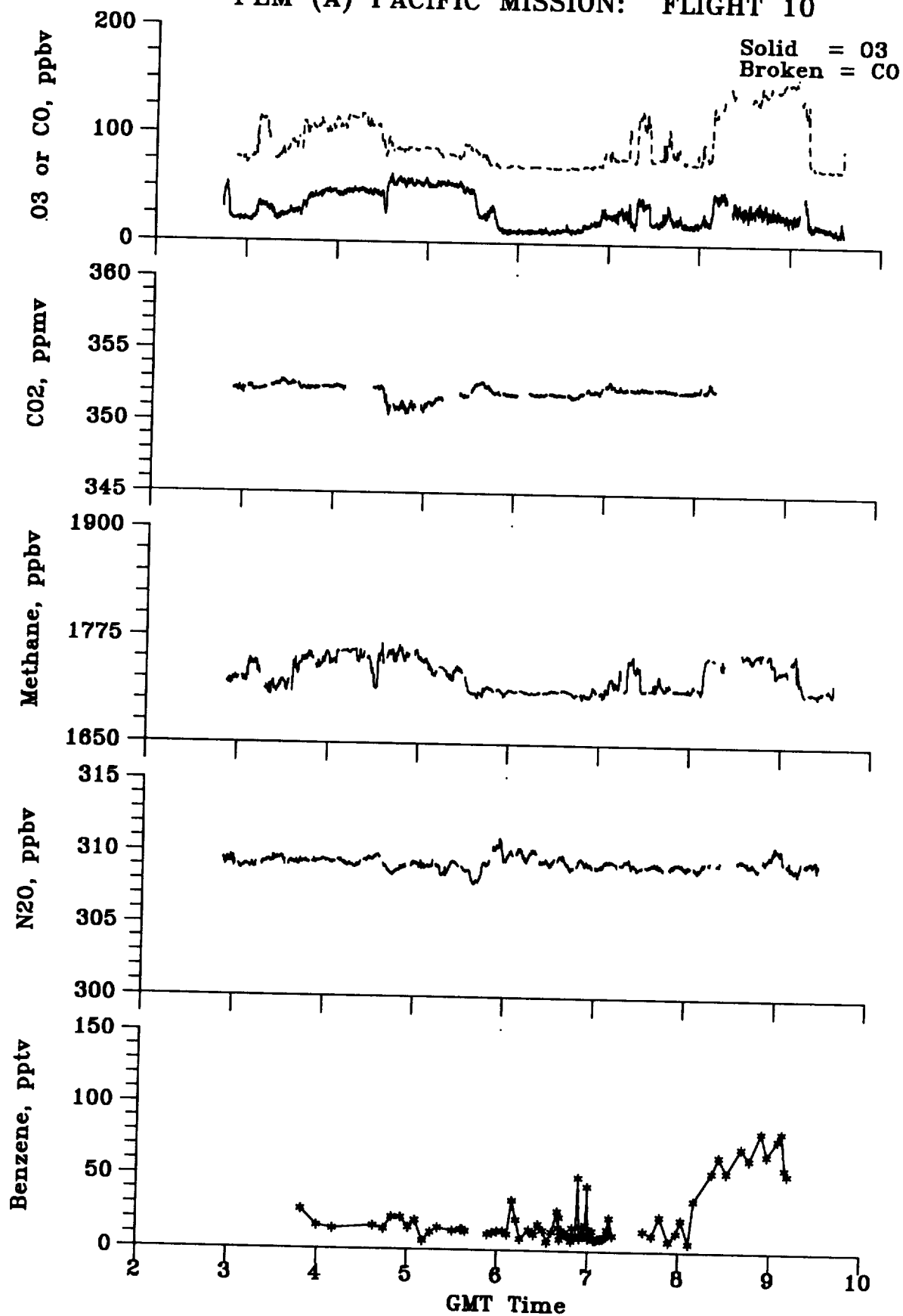


Figure A10.2

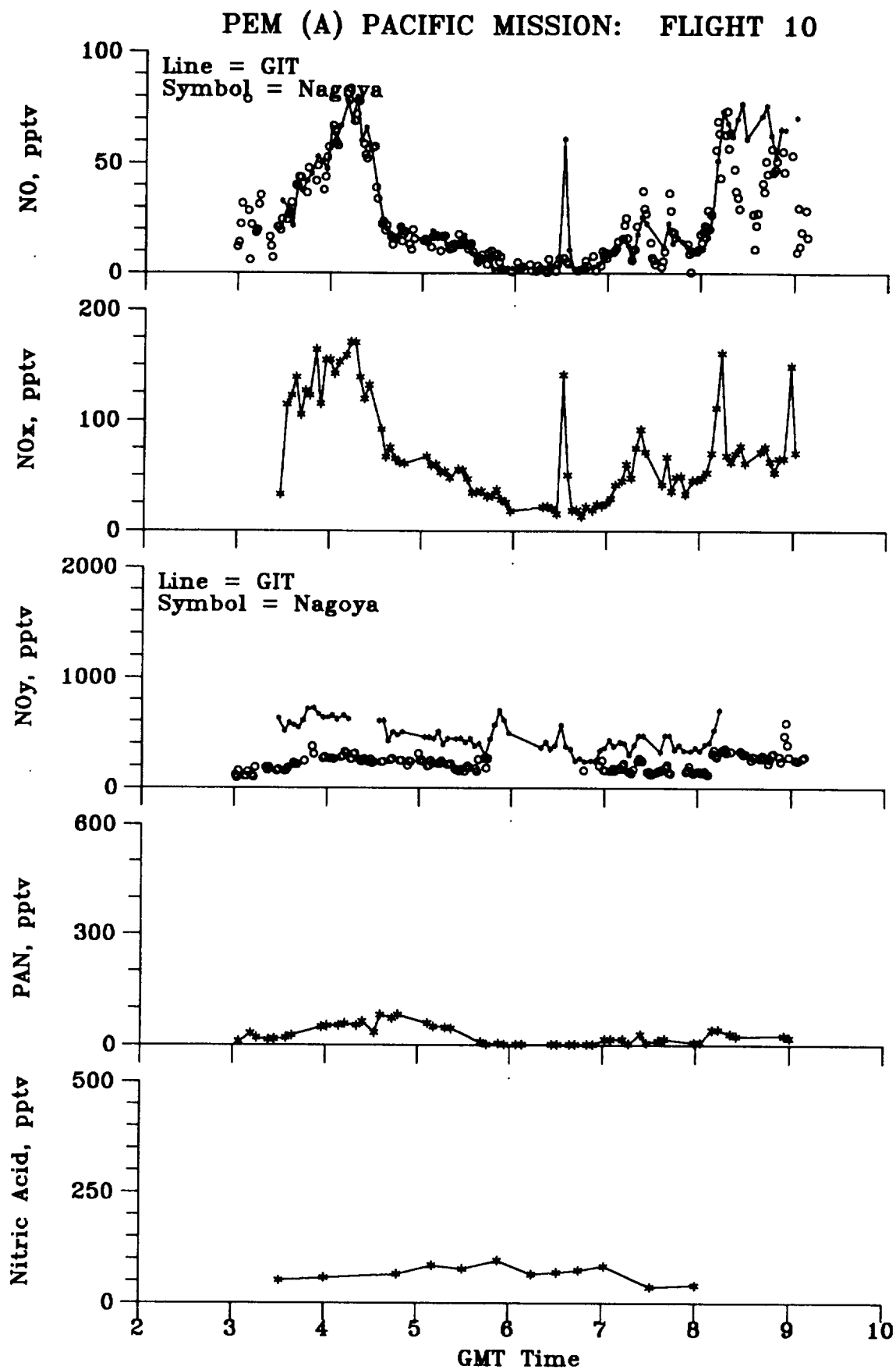


Figure A10.3

# PEM (A) PACIFIC MISSION: FLIGHT 10

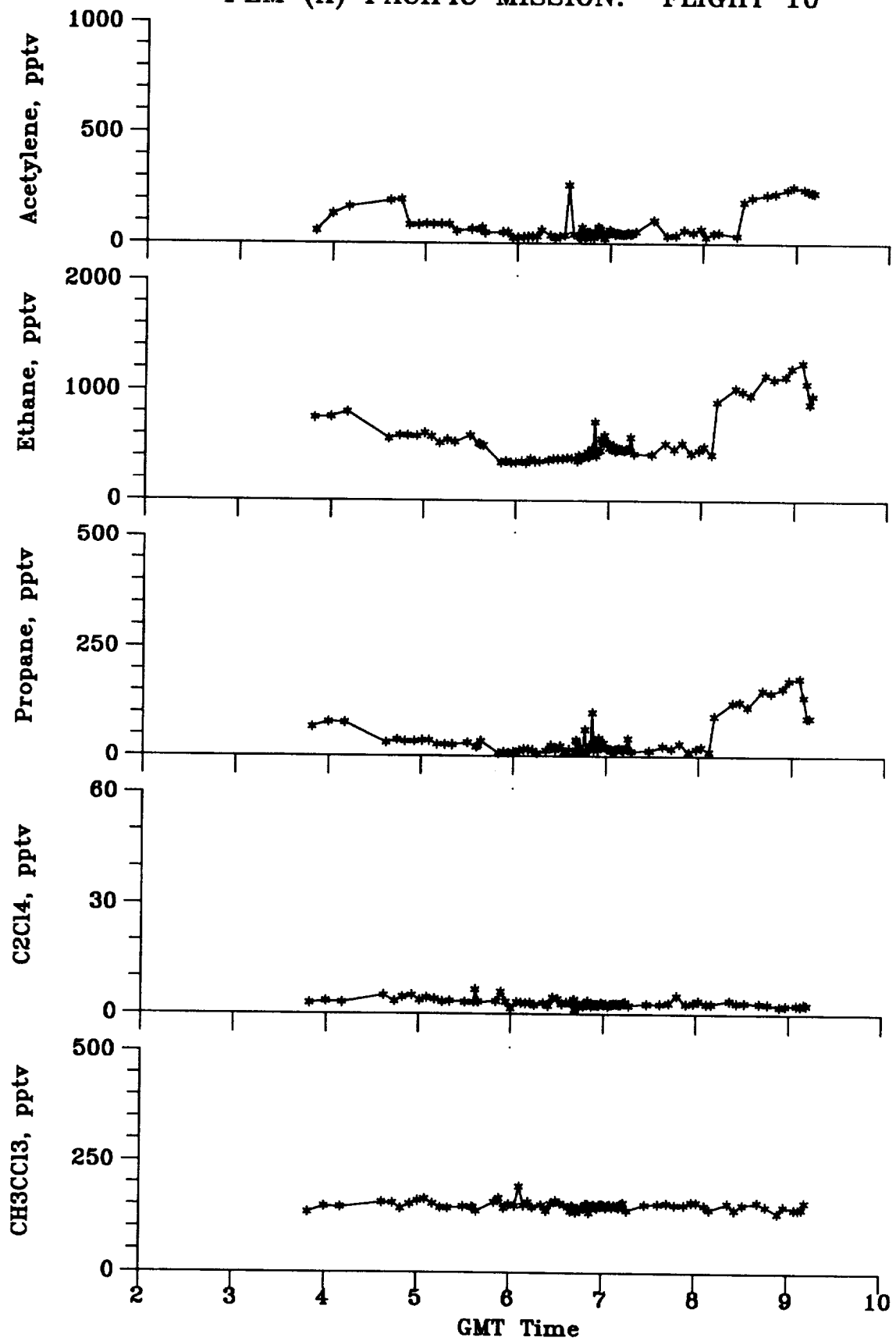


Figure A10.4

# PEM (A) PACIFIC MISSION: FLIGHT 10

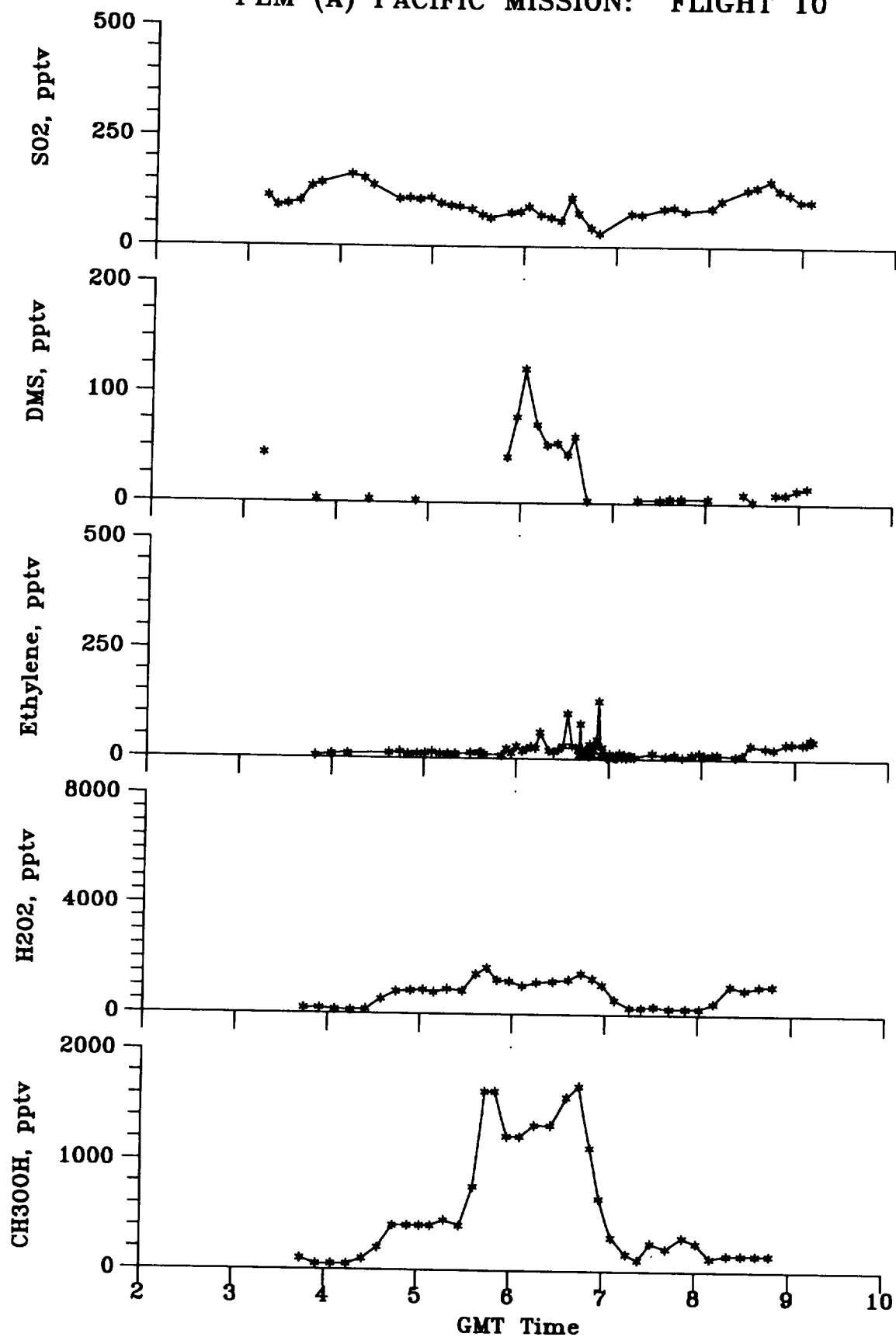
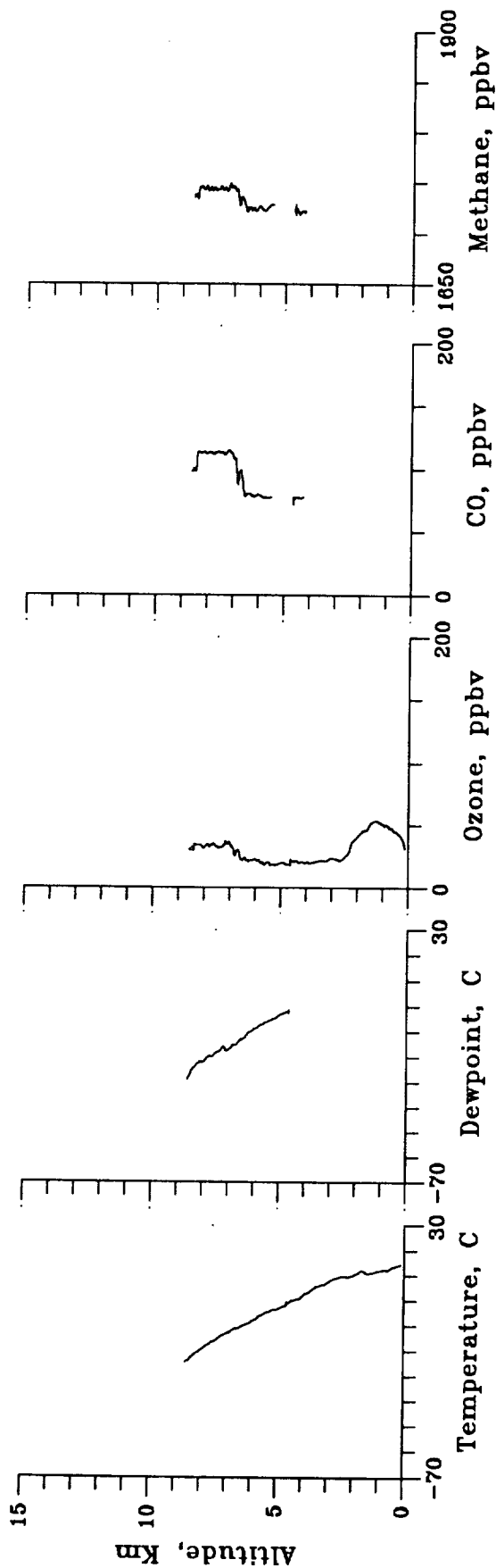


Figure A10.5

PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0300 GMT



PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0700 GMT

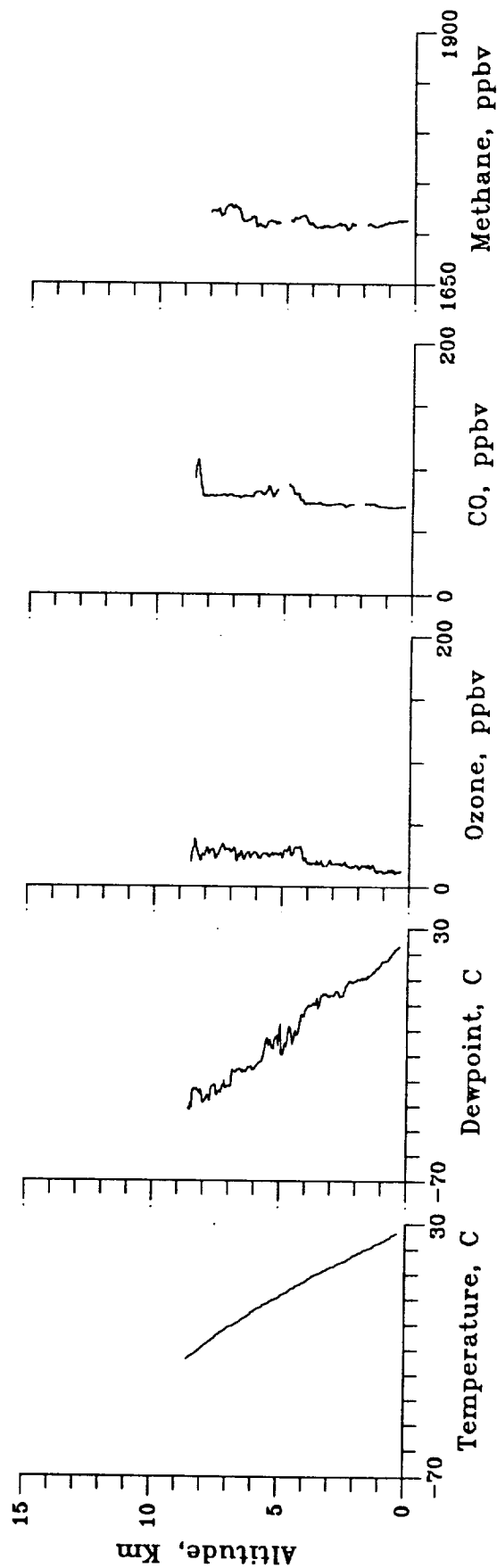


Figure A10.6

PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0915 GMT

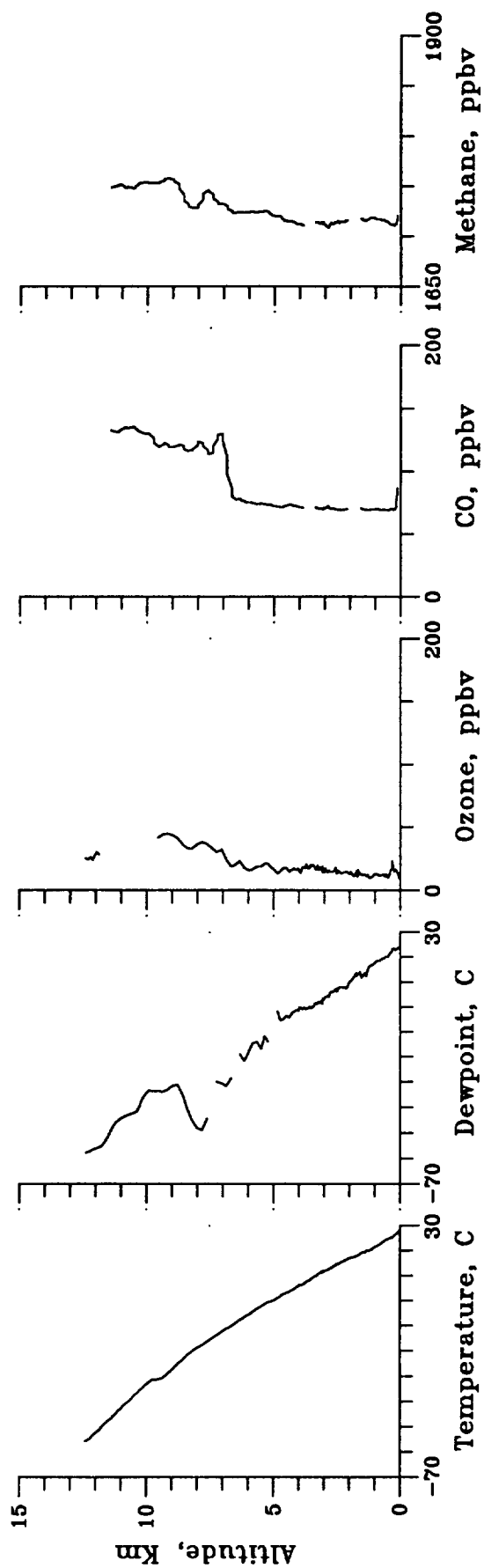


Figure A10.7





# PEM (A) PACIFIC MISSION: FLIGHT 11

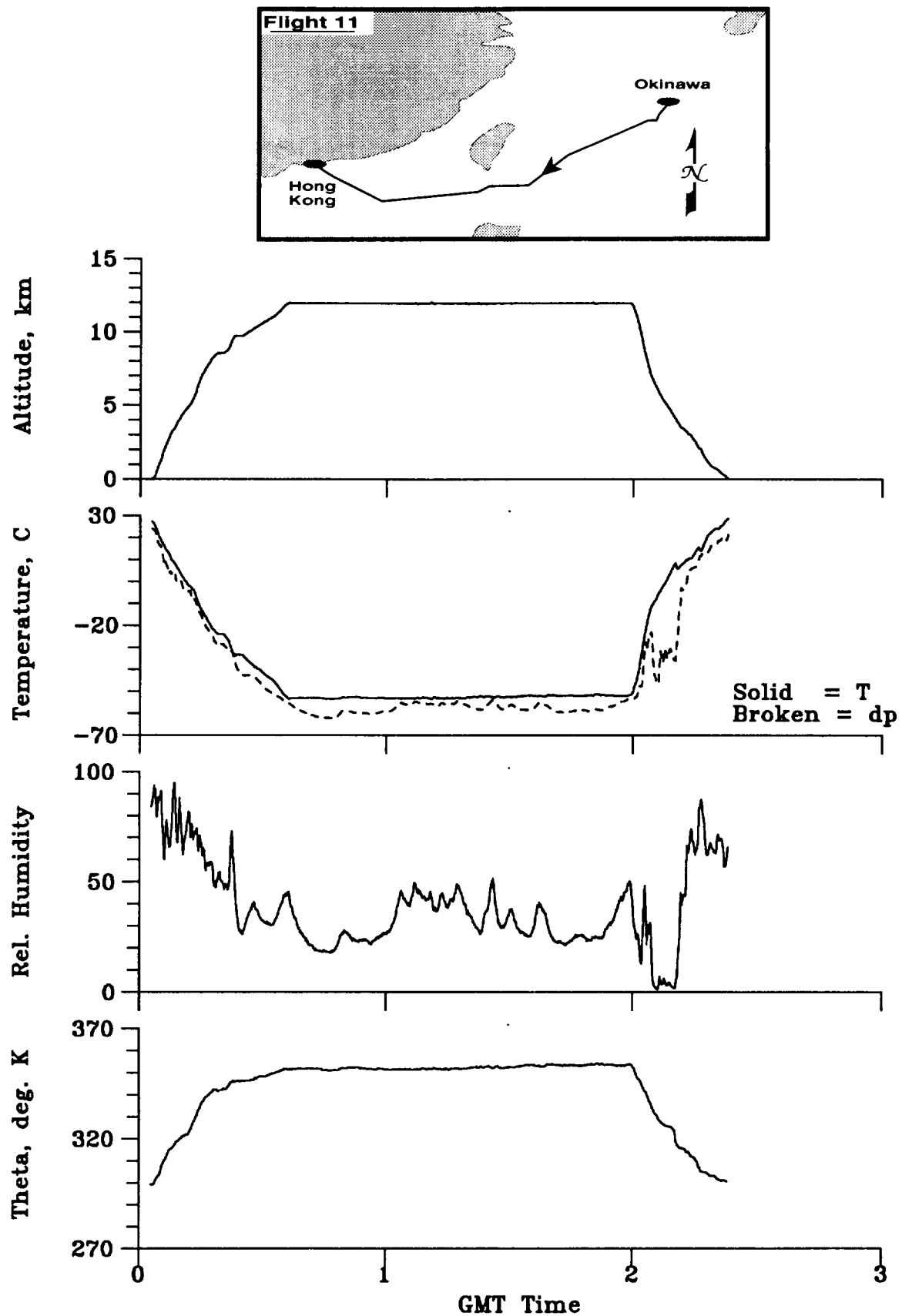


Figure A11.1

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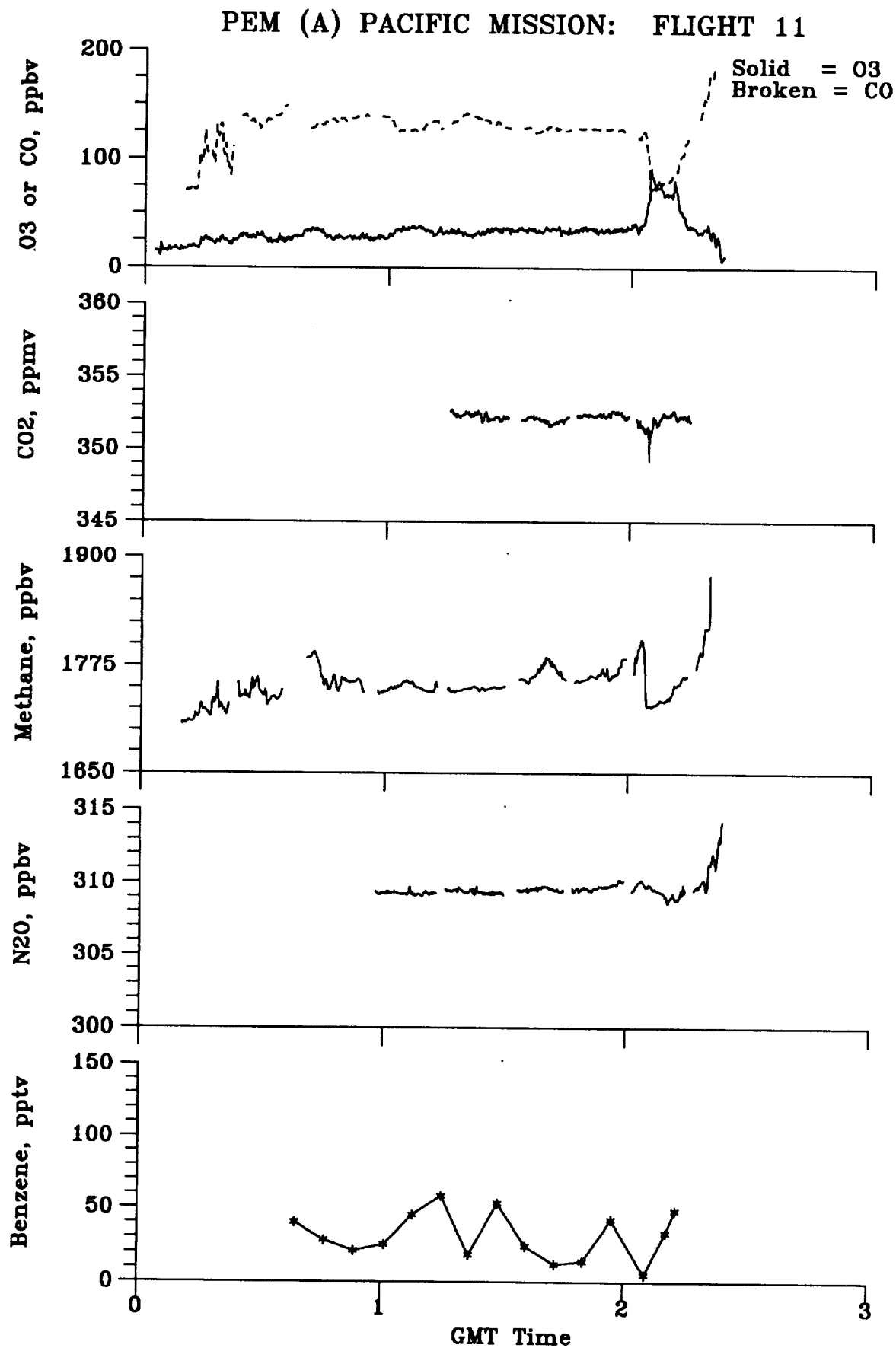


Figure A11.2

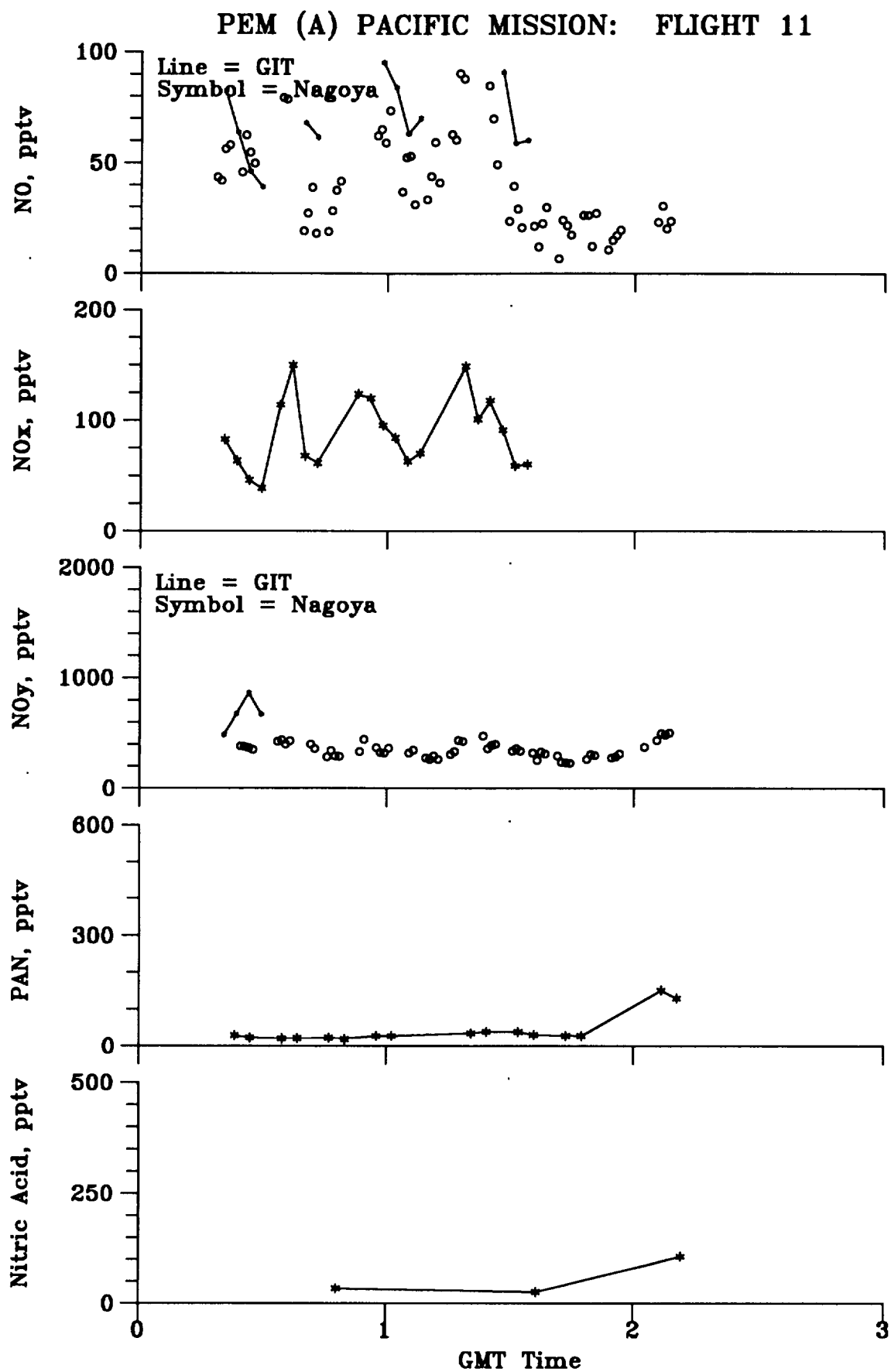


Figure A11.3

# PEM (A) PACIFIC MISSION: FLIGHT 11

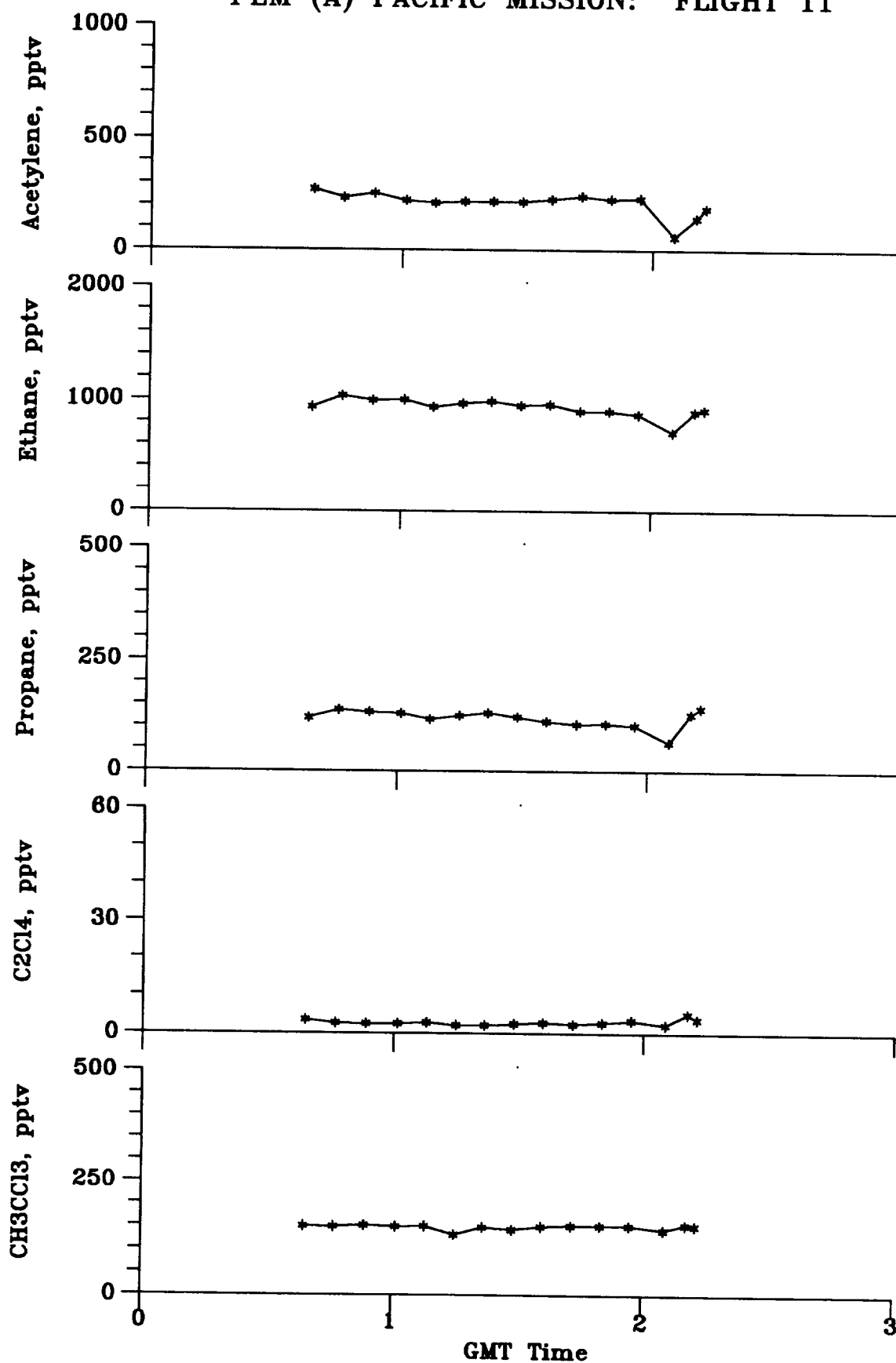


Figure A11.4

# PEM (A) PACIFIC MISSION: FLIGHT 11

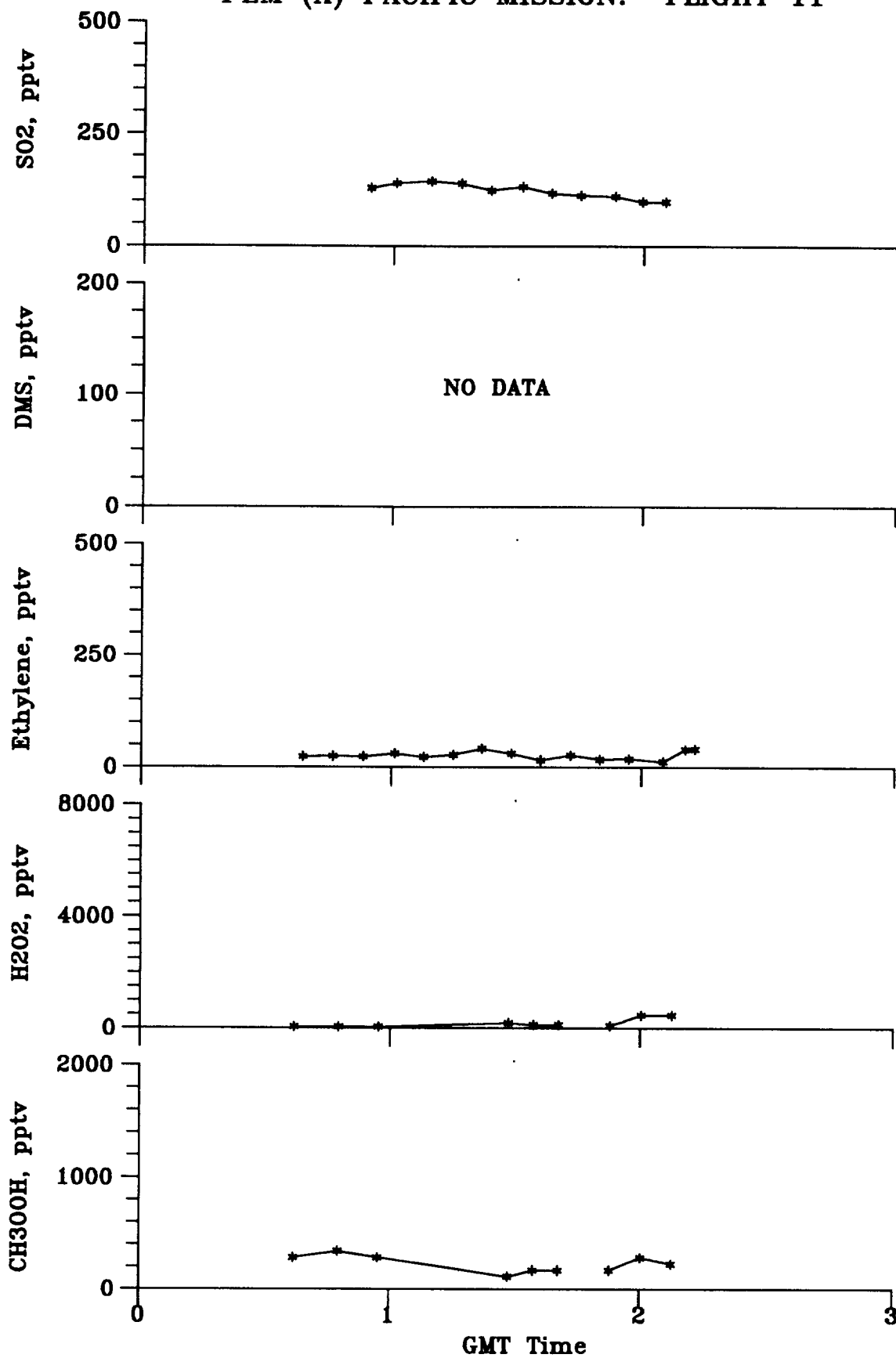
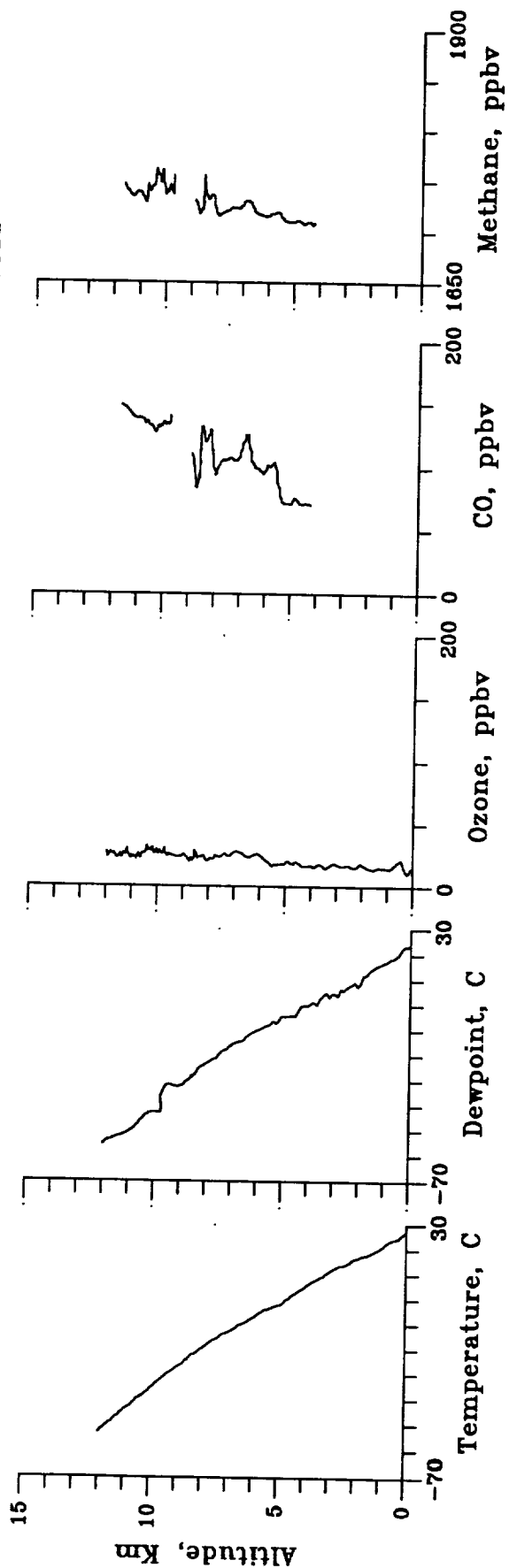


Figure A11.5

PEM (A) PACIFIC MISSION: FLIGHT 11 PROFILE AT 0015 GMT



PEM (A) PACIFIC MISSION: FLIGHT 11 PROFILE AT 0215 GMT

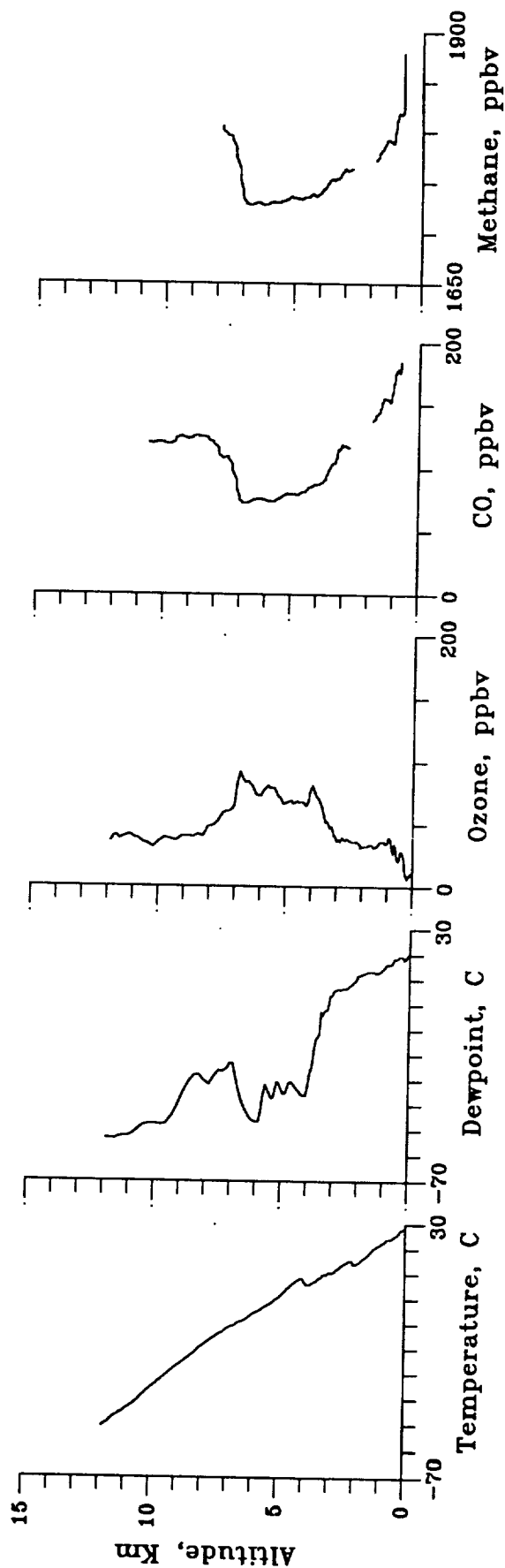


Figure A11.6

# PEM (A) PACIFIC MISSION: FLIGHT 12

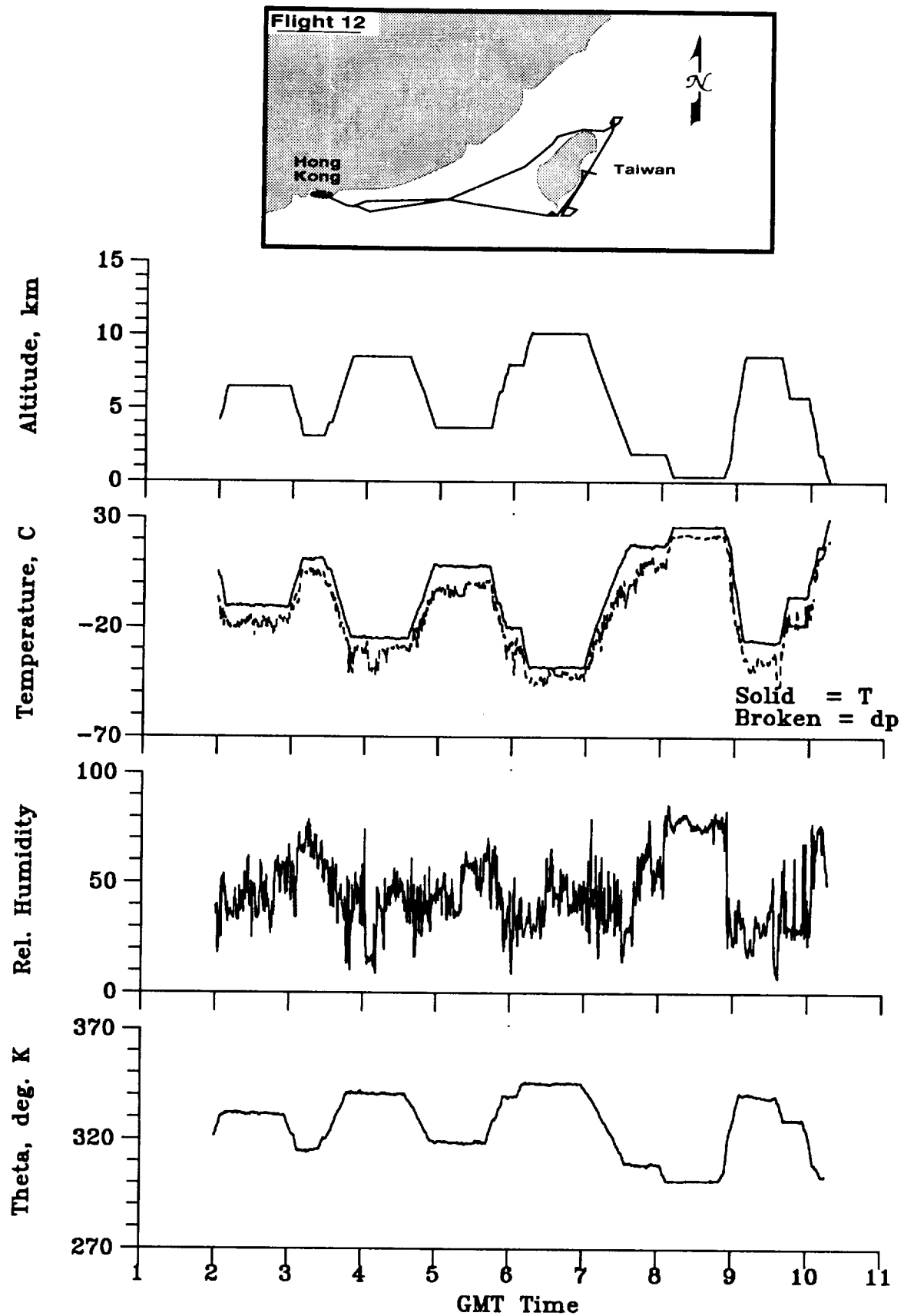


Figure A12.1

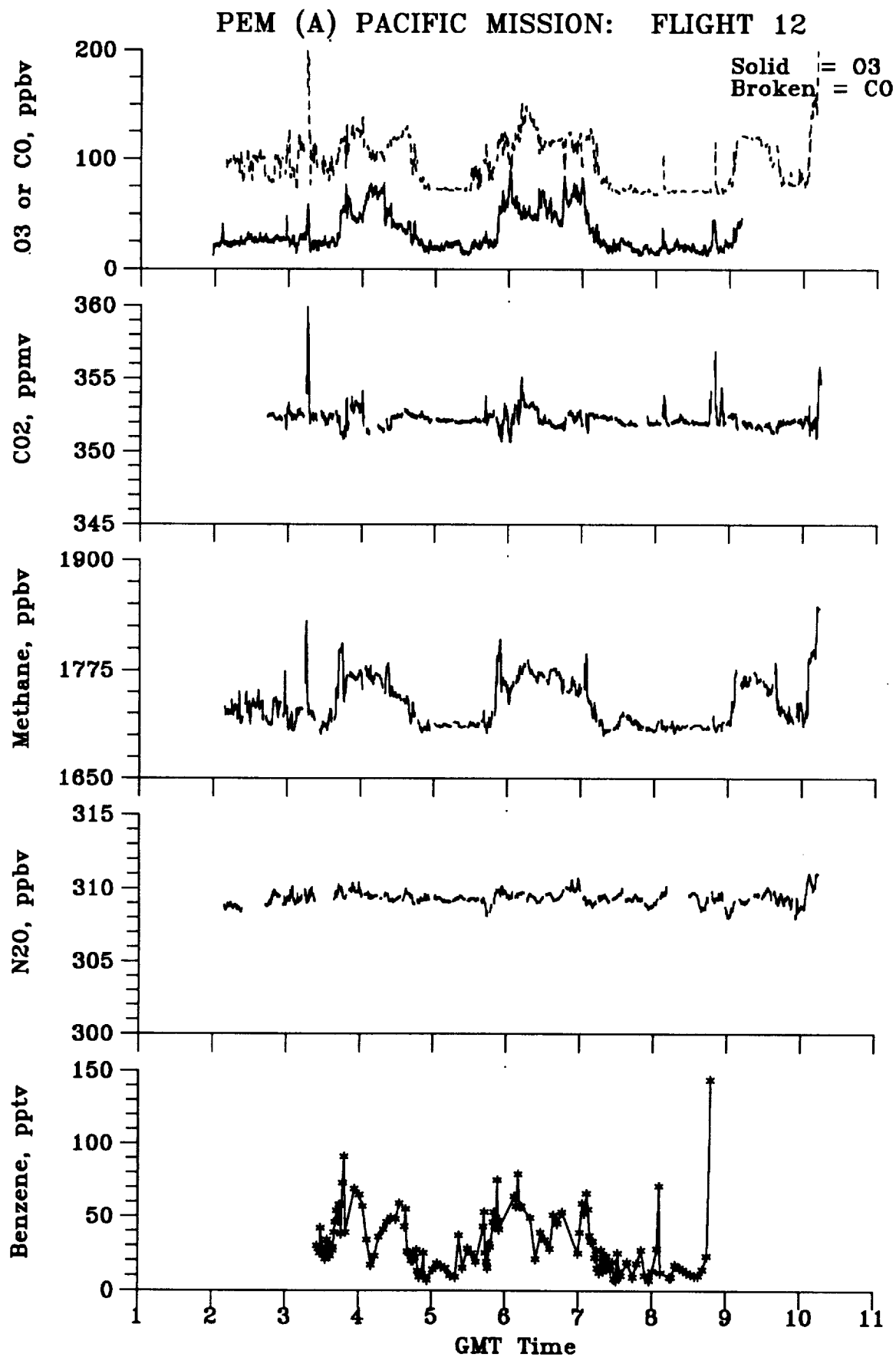


Figure A12.2



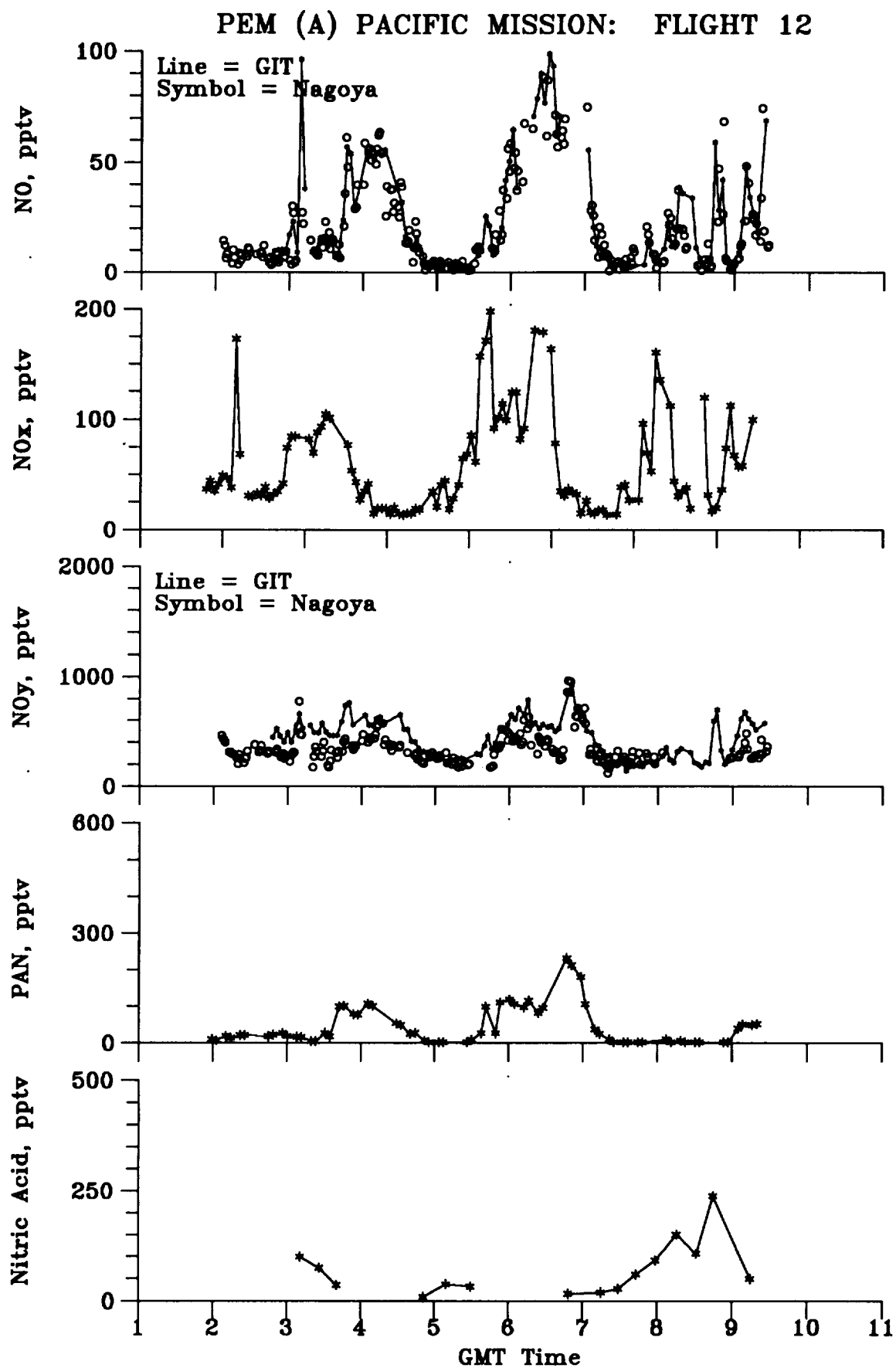


Figure A12.3

# PEM (A) PACIFIC MISSION: FLIGHT 12

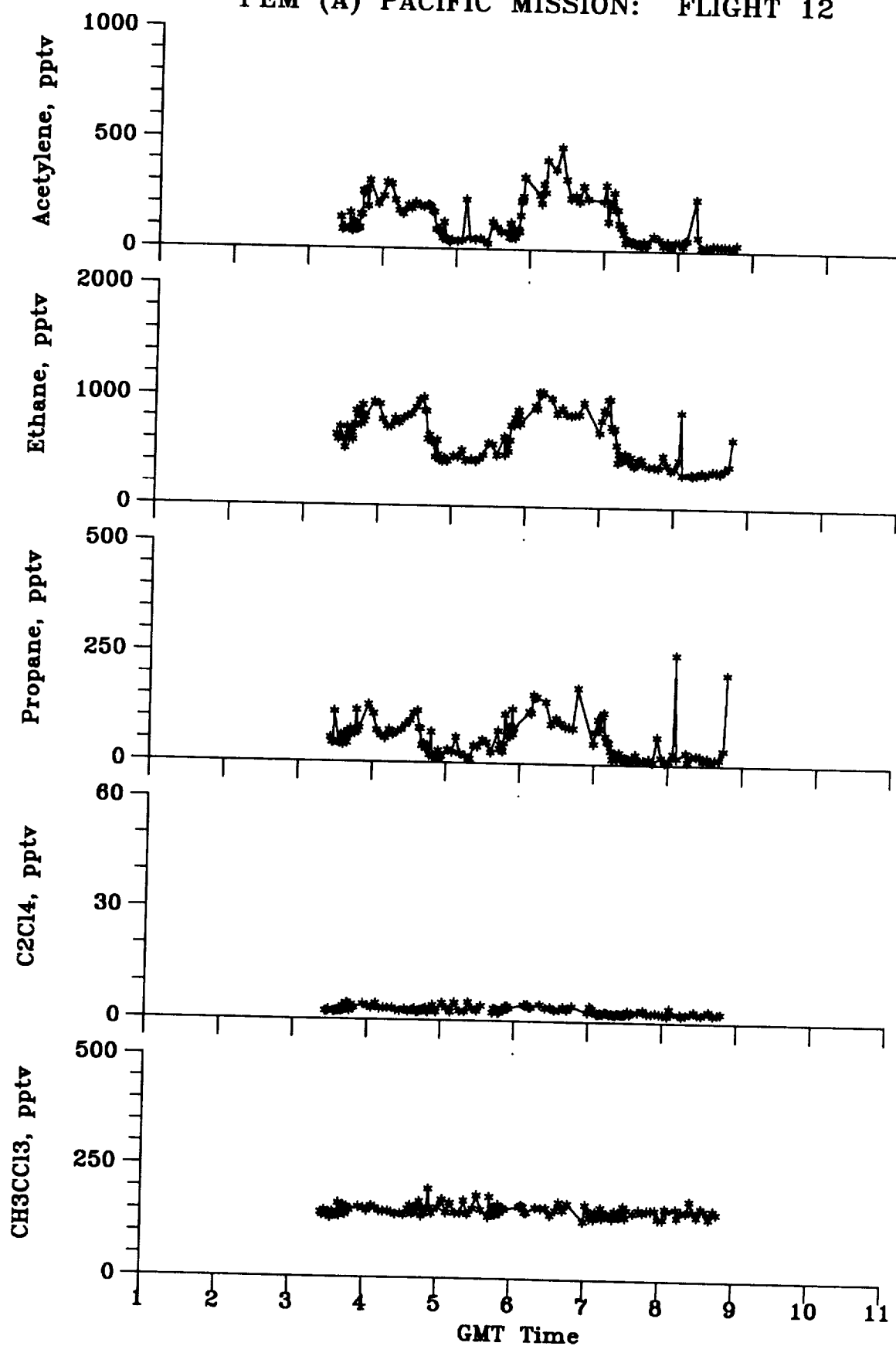


Figure A12.4

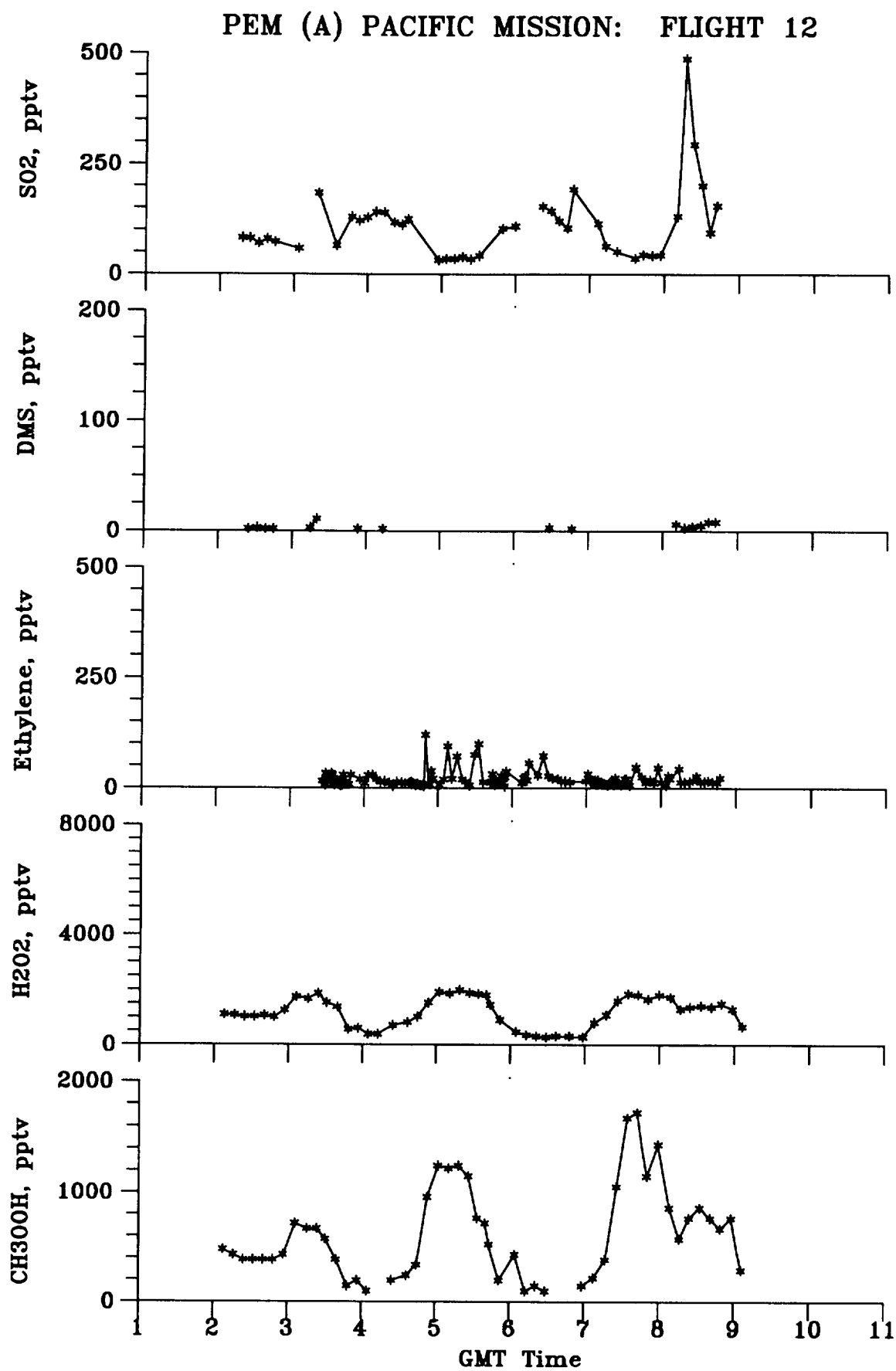


Figure A12.5

PEM (A) PACIFIC MISSION: FLIGHT 12 PROFILE AT 0900 GMT

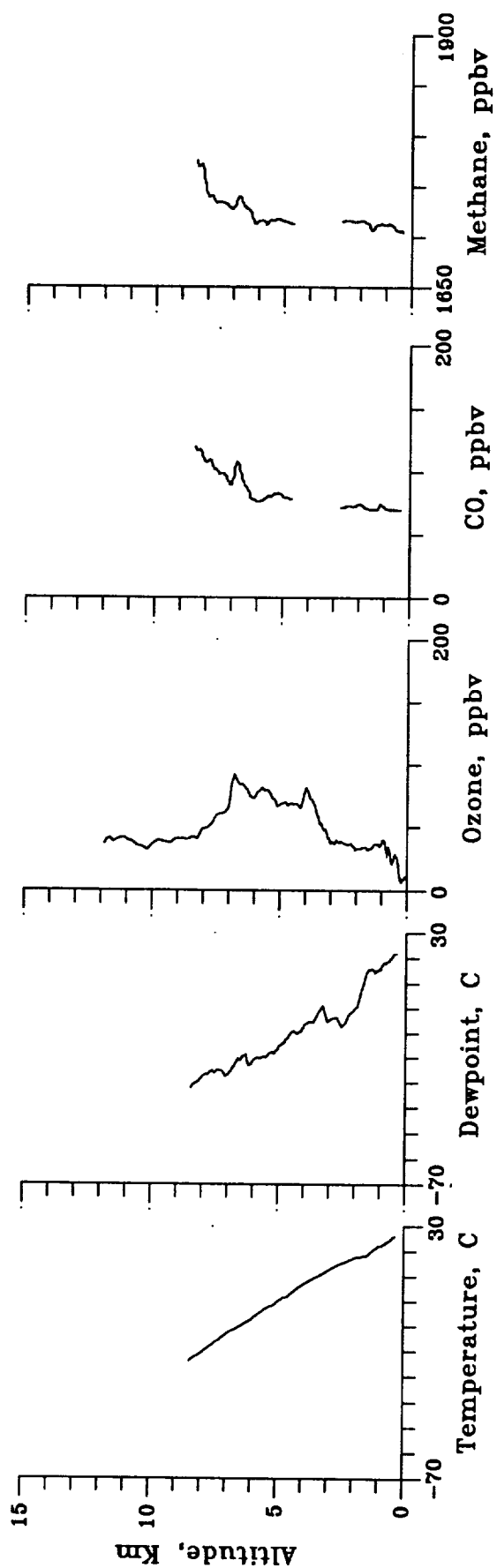


Figure A12.6

# PEM (A) PACIFIC MISSION: FLIGHT 13

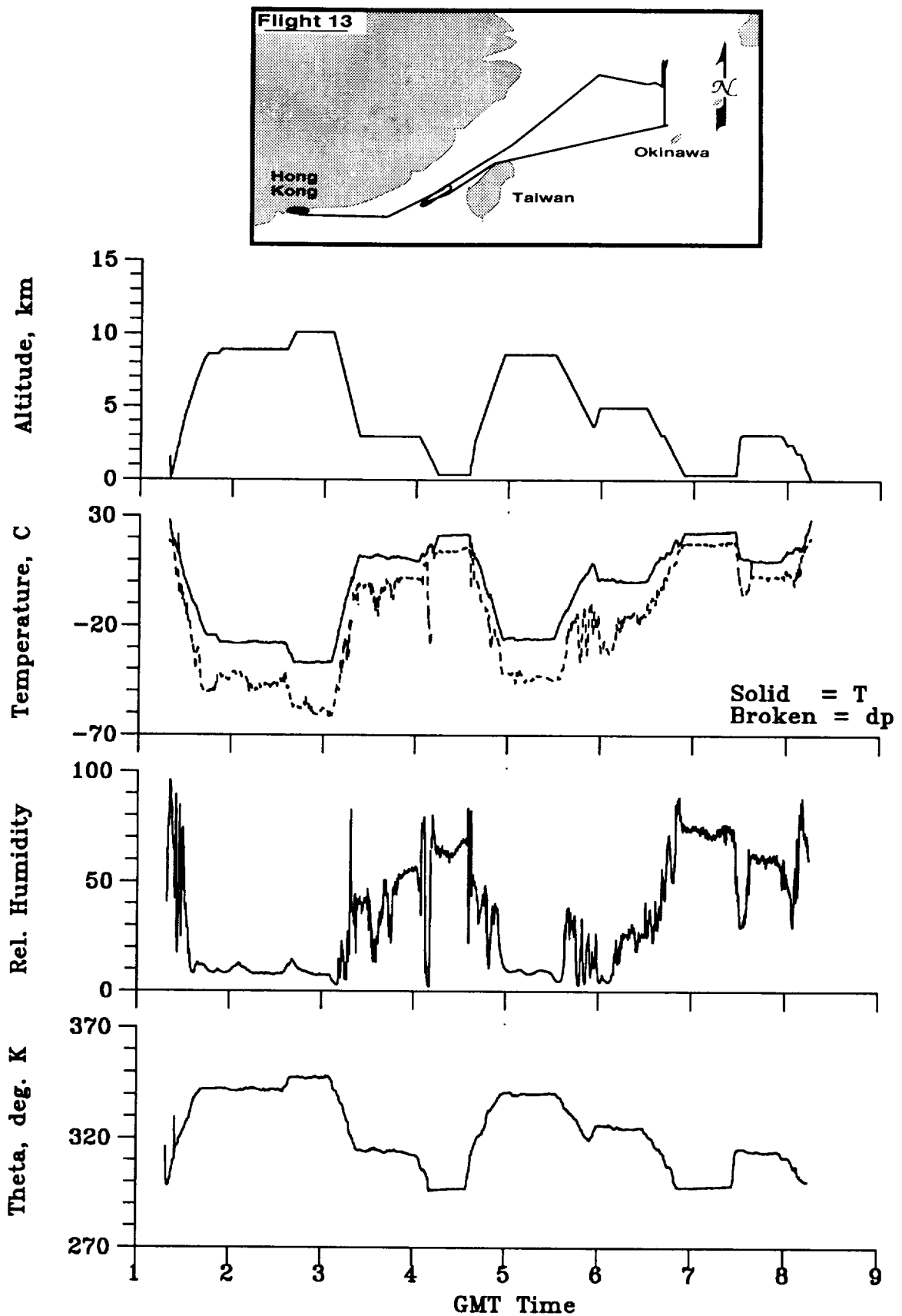


Figure A13.1

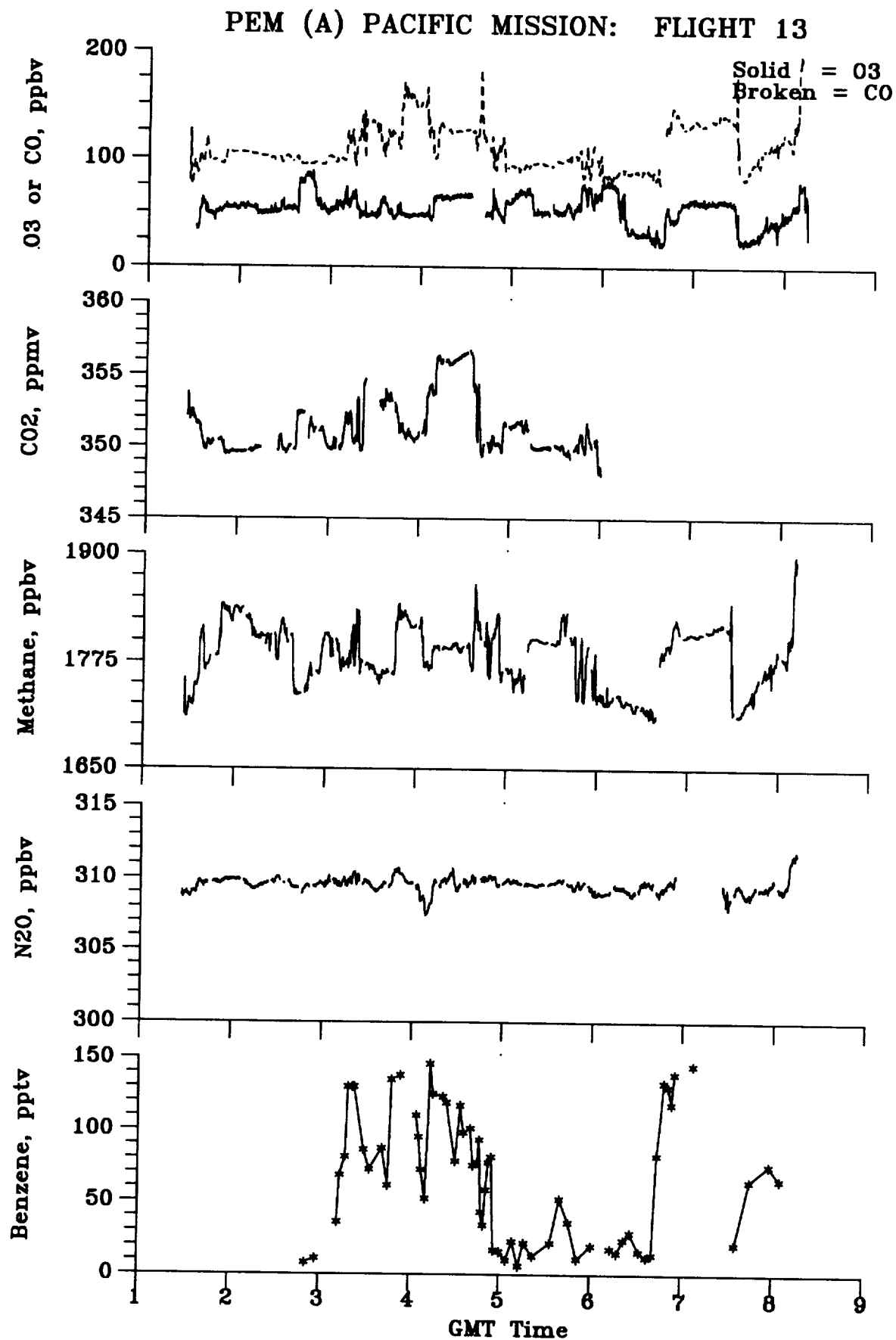


Figure A13.2

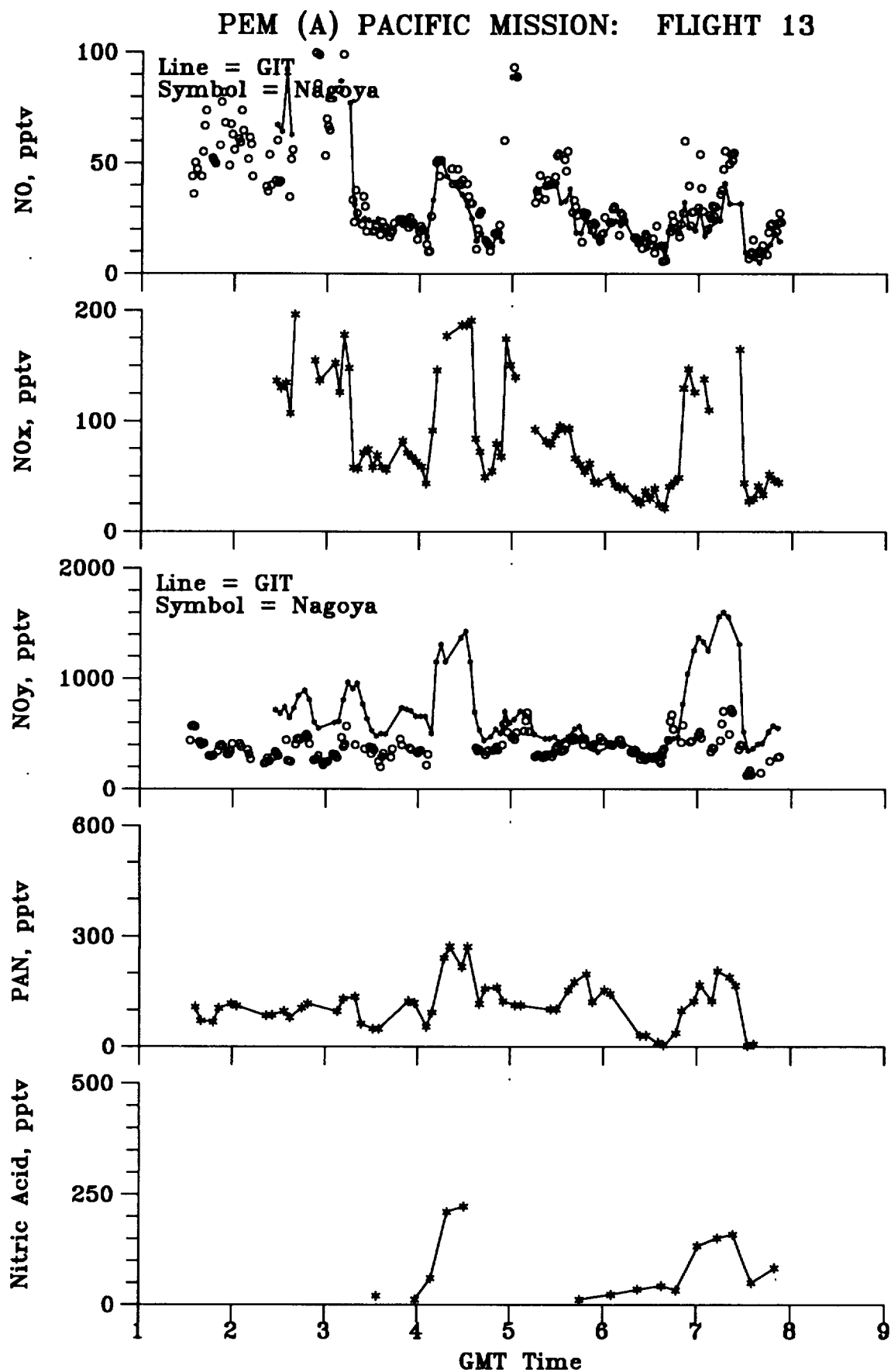


Figure A13.3

# PEM (A) PACIFIC MISSION: FLIGHT 13

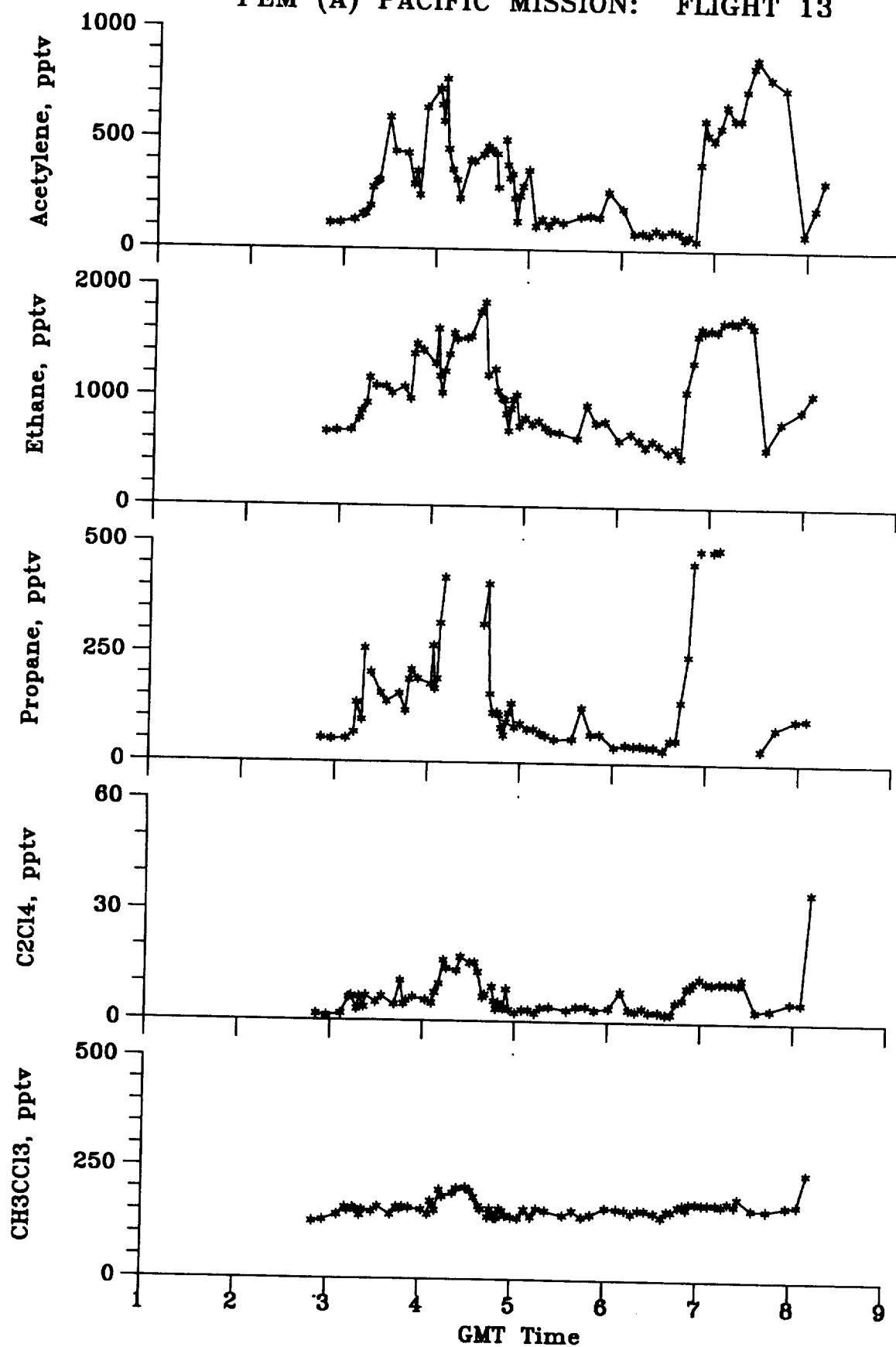


Figure A13.4



# PEM (A) PACIFIC MISSION: FLIGHT 13

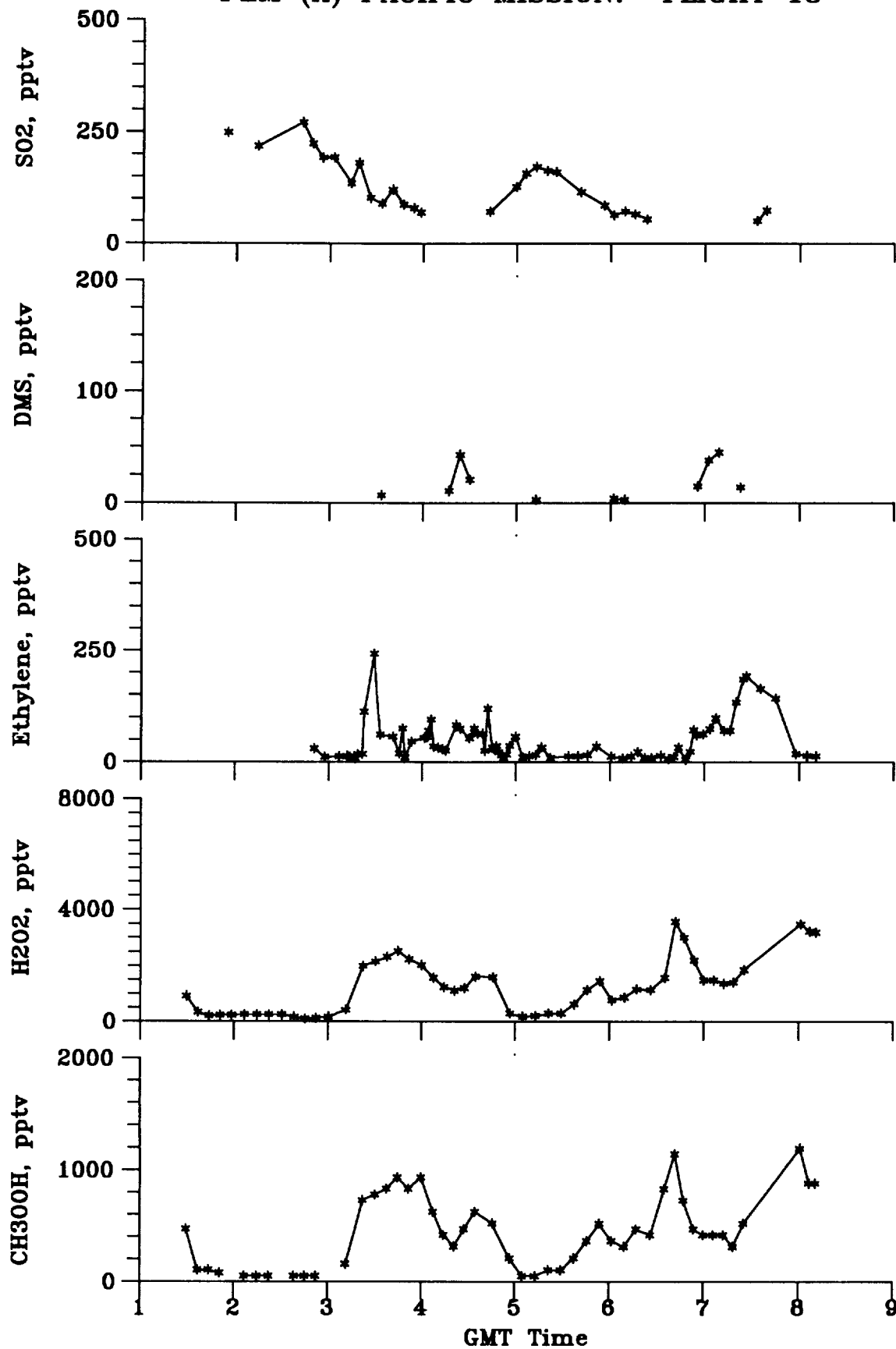
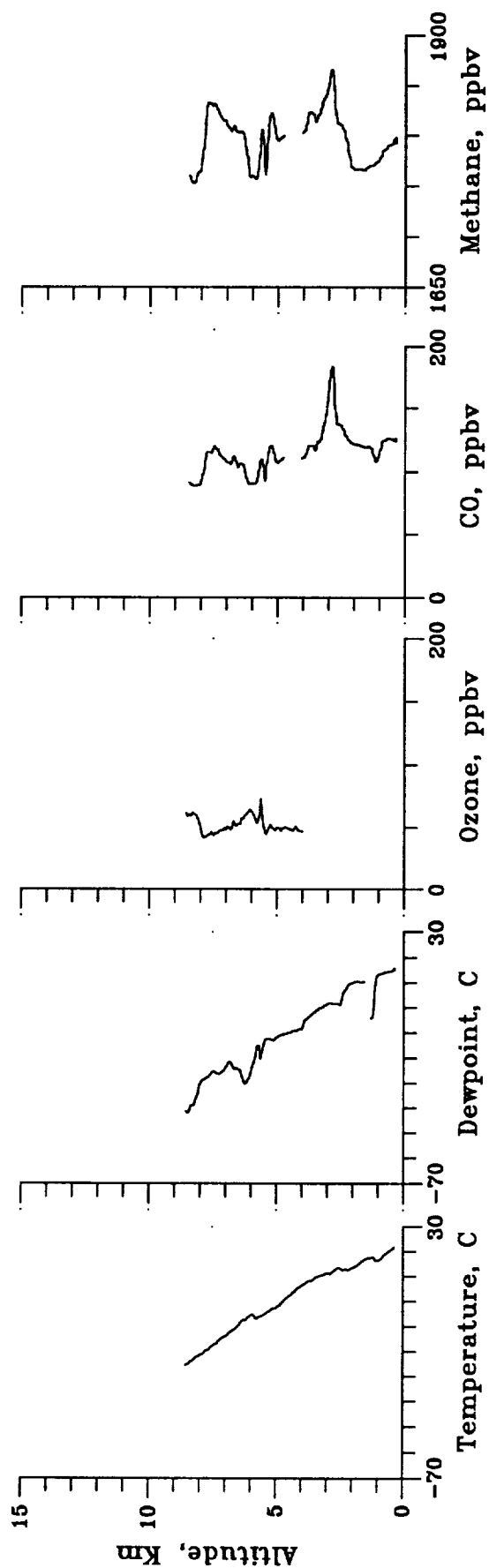


Figure A13.5

PEM (A) PACIFIC MISSION: FLIGHT 13 PROFILE AT 0445 GMT



PEM (A) PACIFIC MISSION: FLIGHT 13 PROFILE AT 0645 GMT

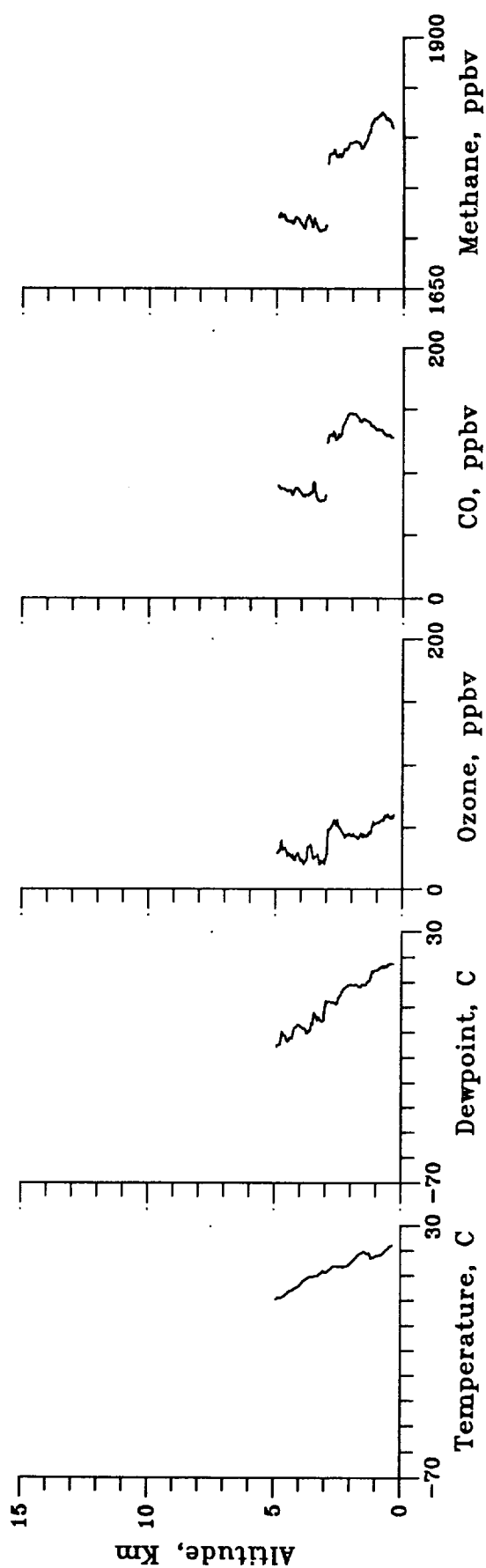


Figure A13.6

# PEM (A) PACIFIC MISSION: FLIGHT 14

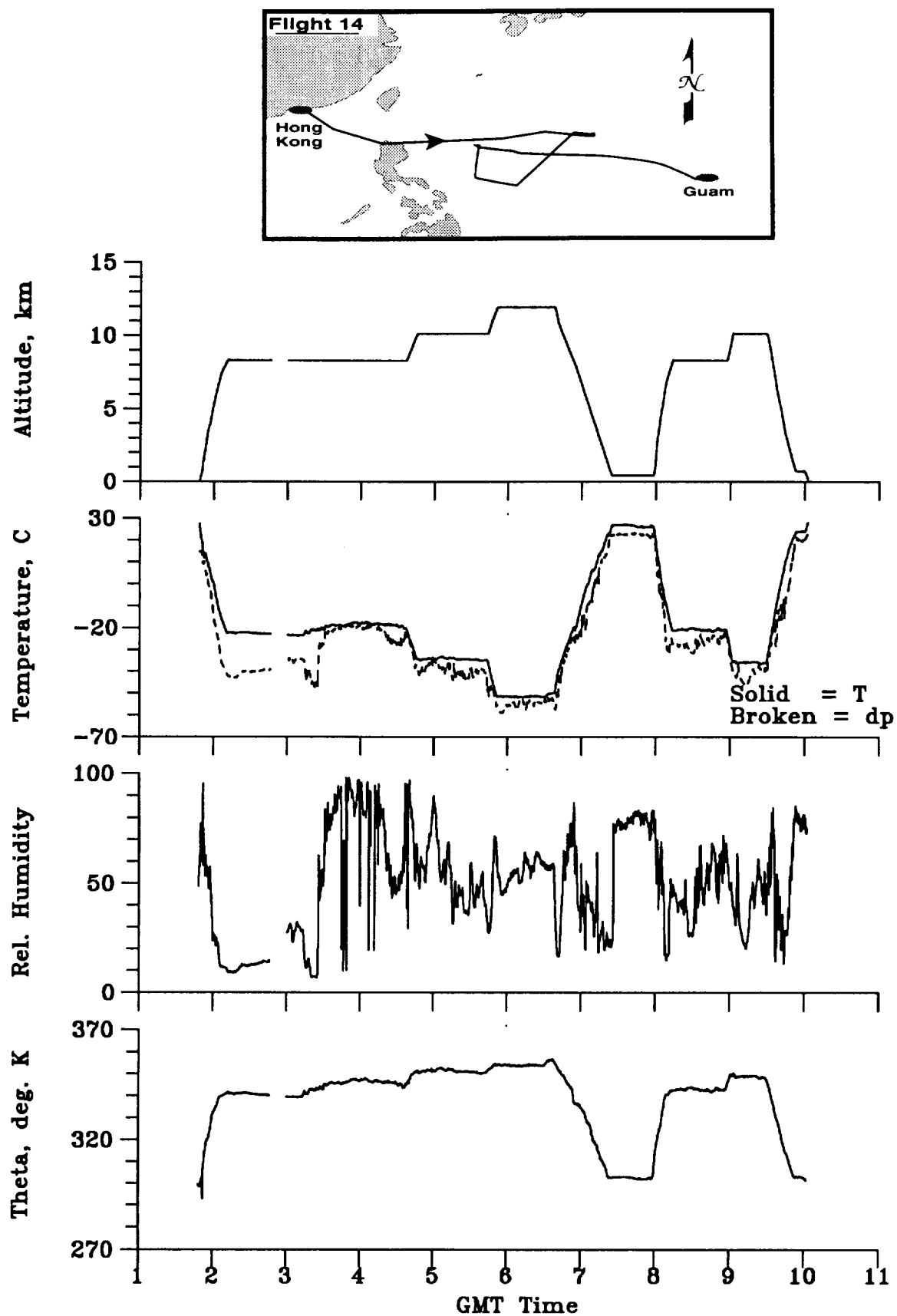


Figure A14.1

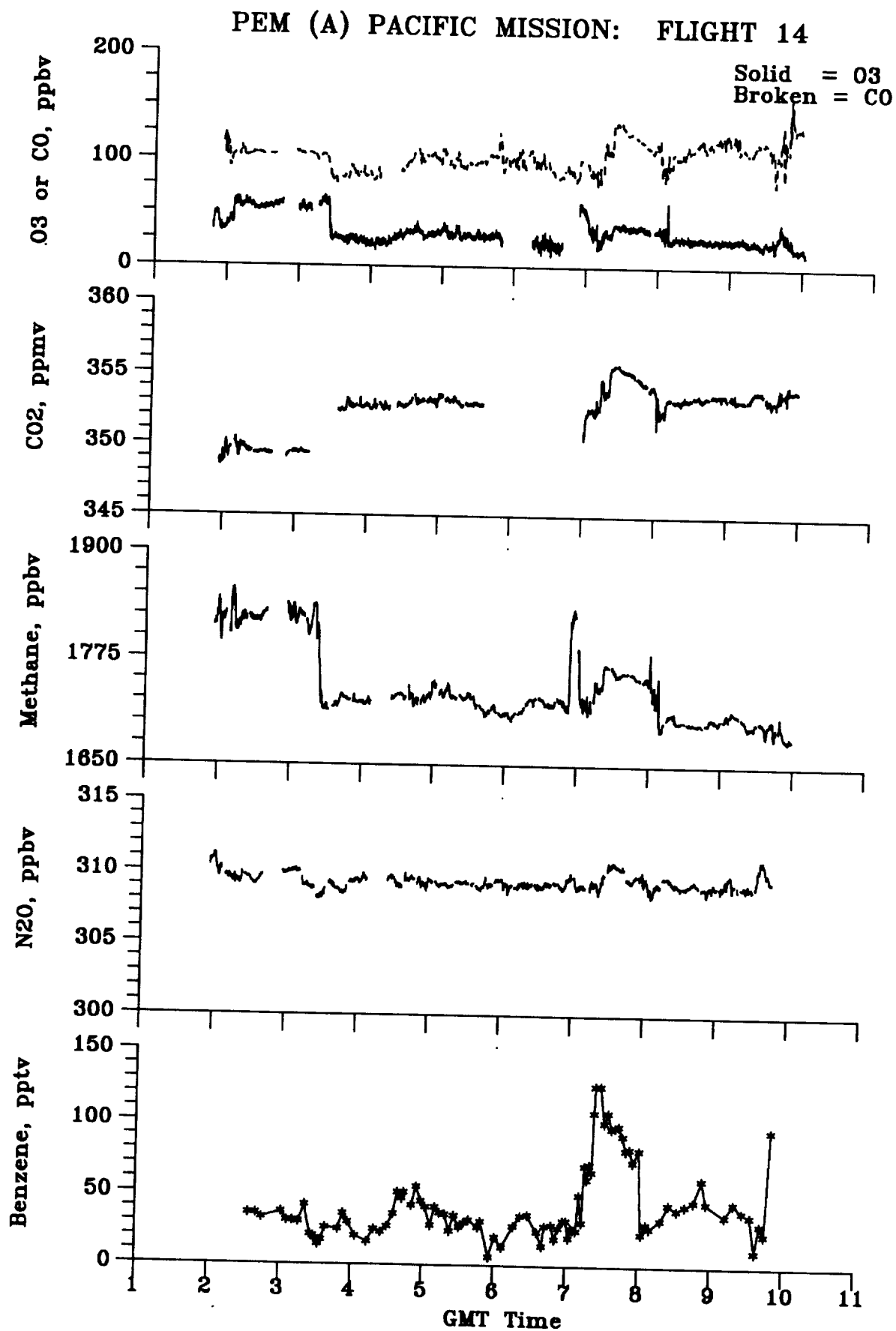


Figure A14.2

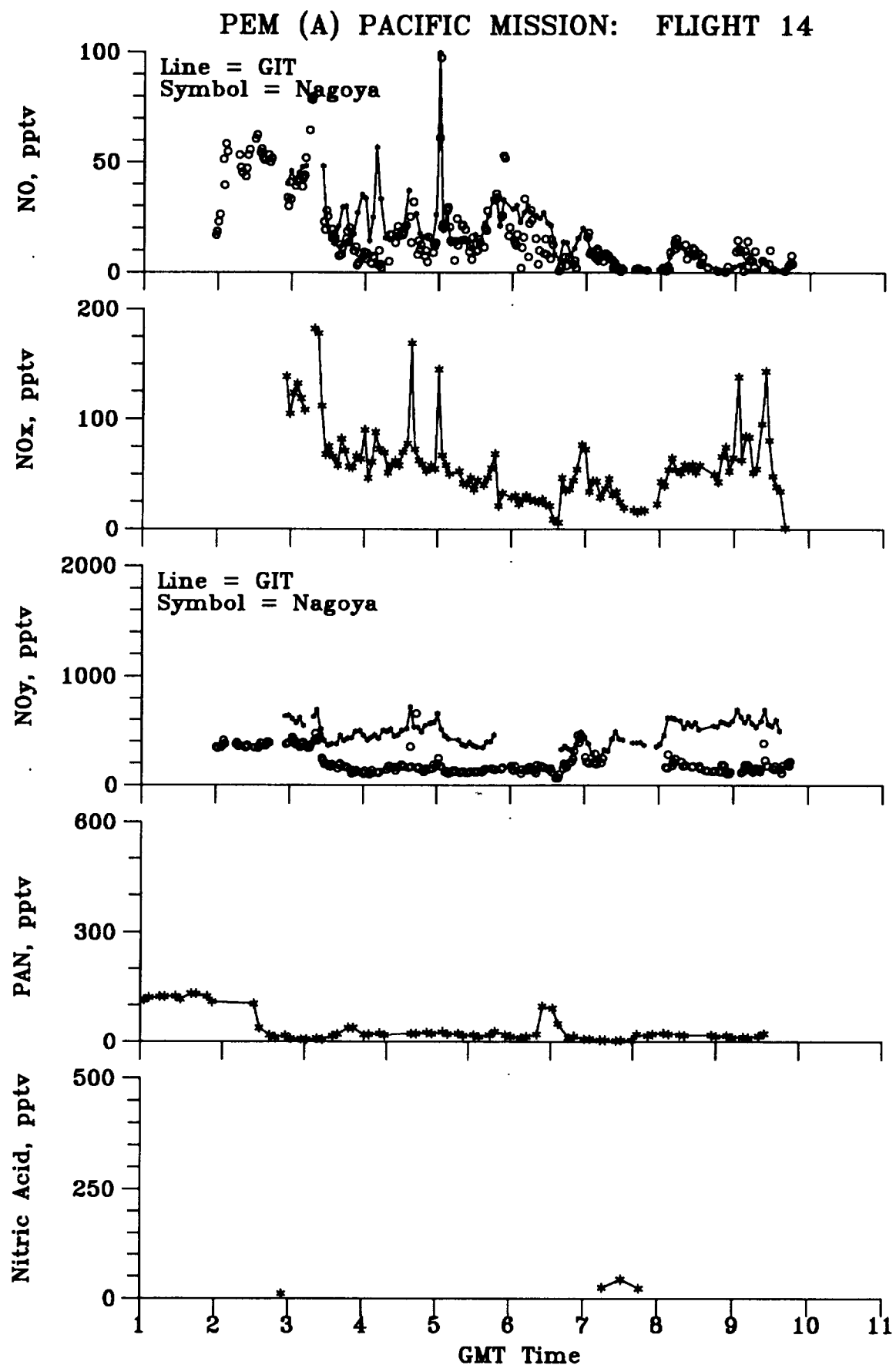


Figure A14.3

PEM (A) PACIFIC MISSION: FLIGHT 14

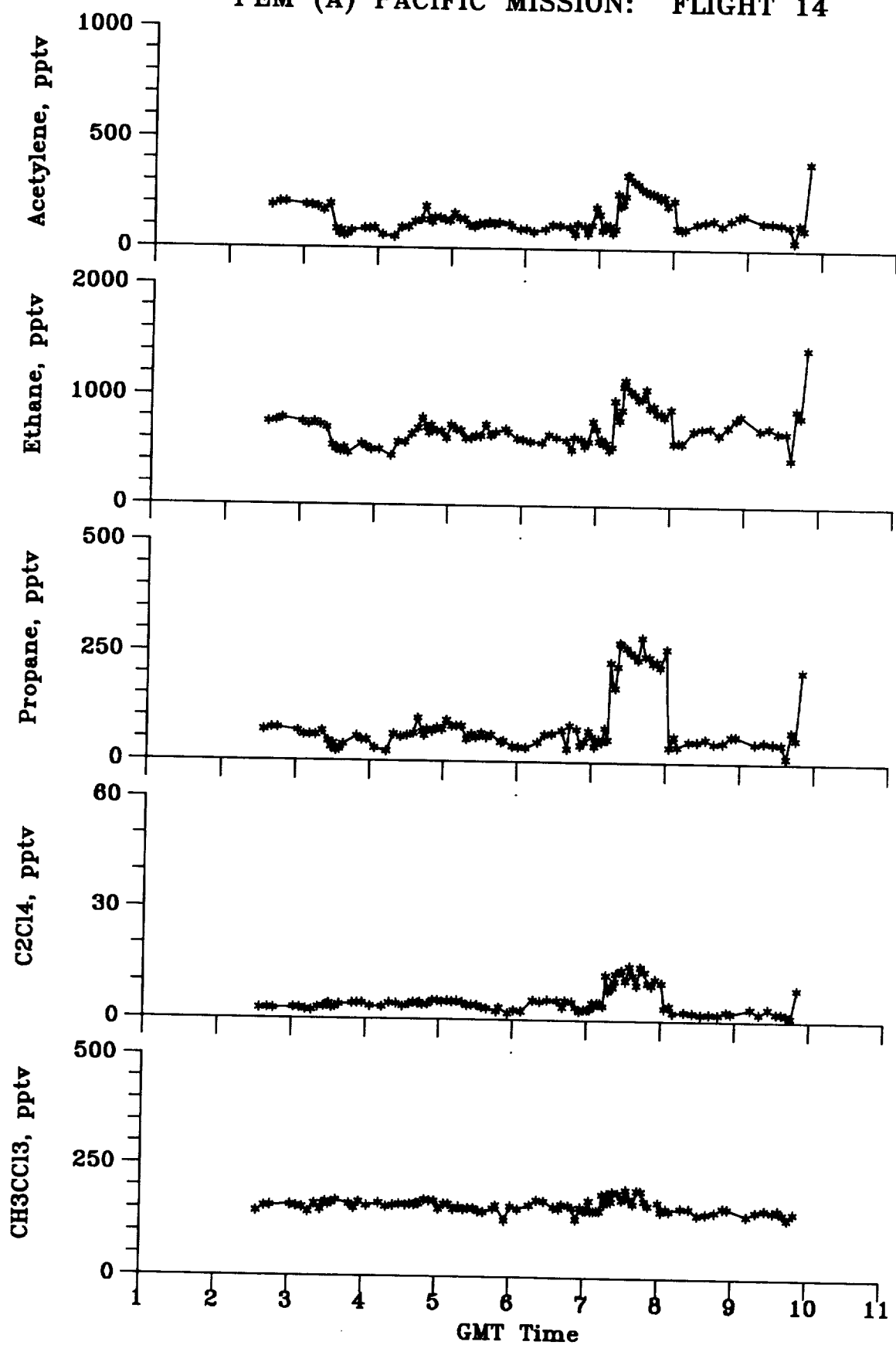


Figure A14.4

# PEM (A) PACIFIC MISSION: FLIGHT 14

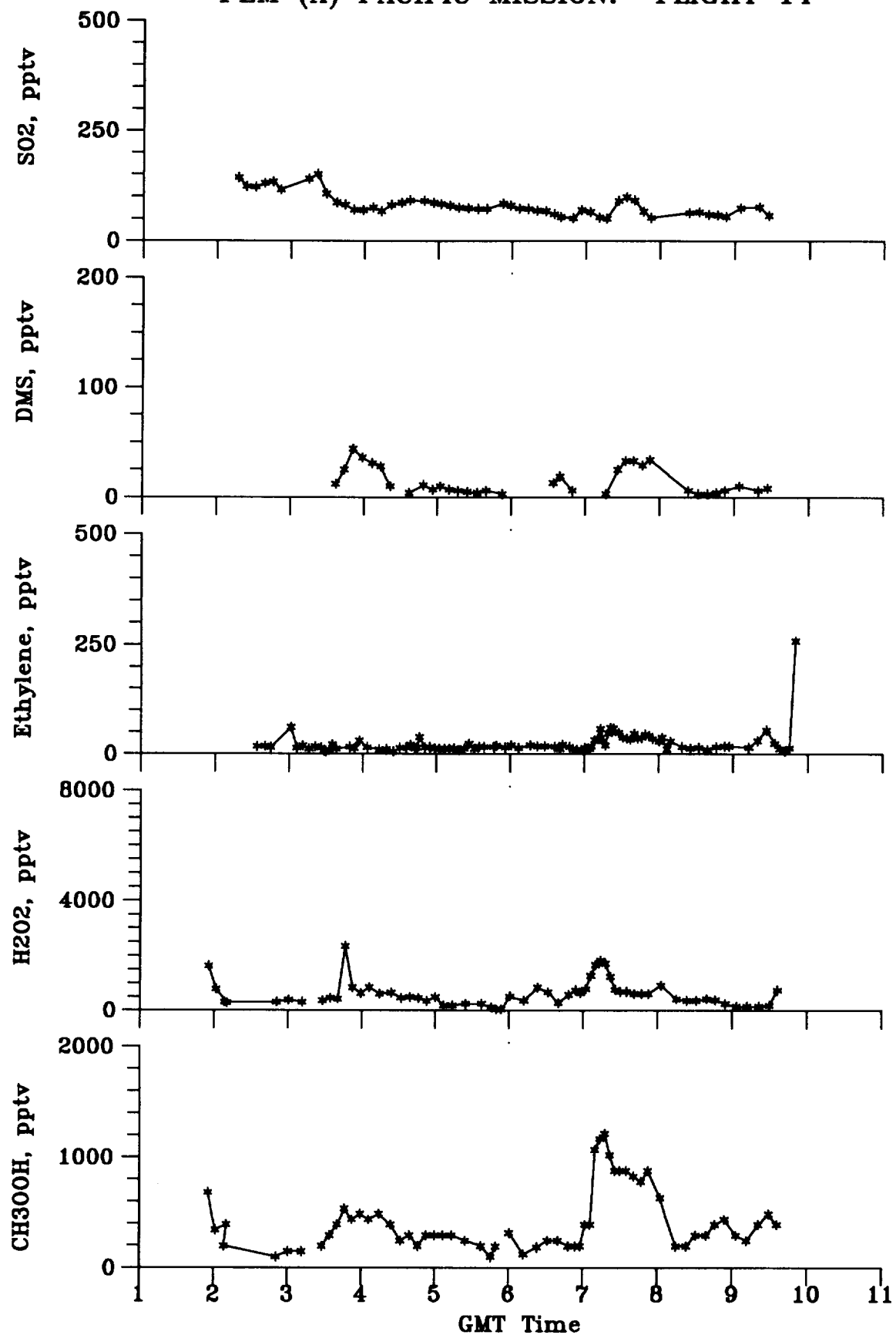
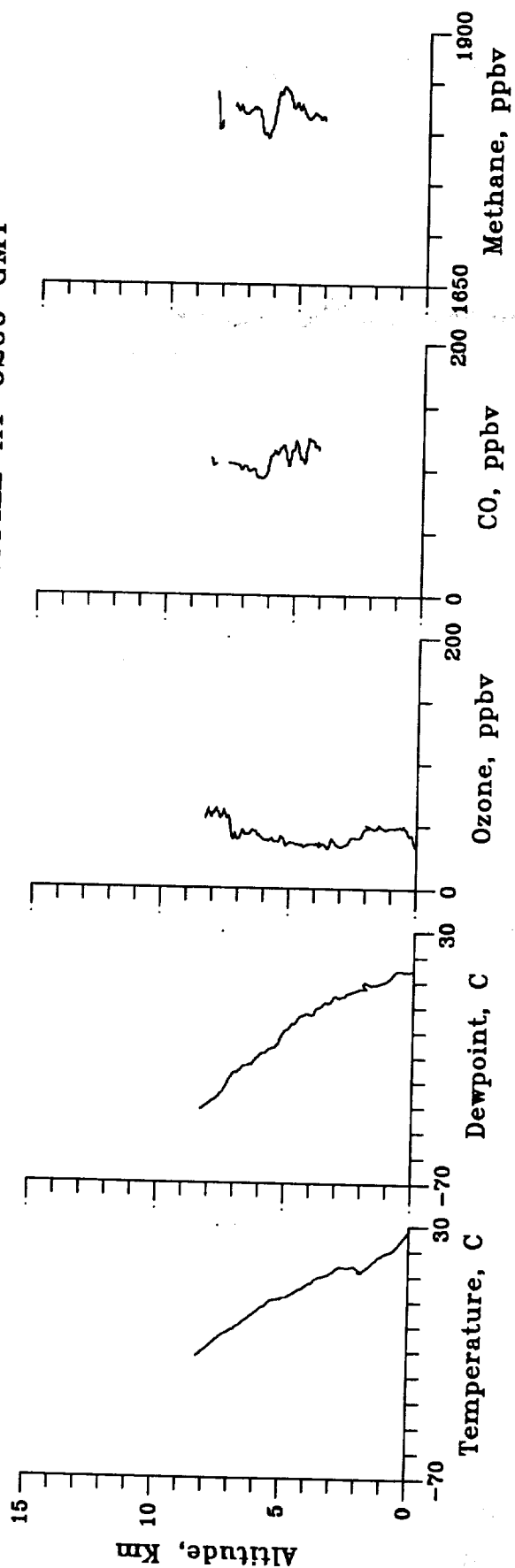


Figure A14.5

PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0200 GMT



PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0700 GMT

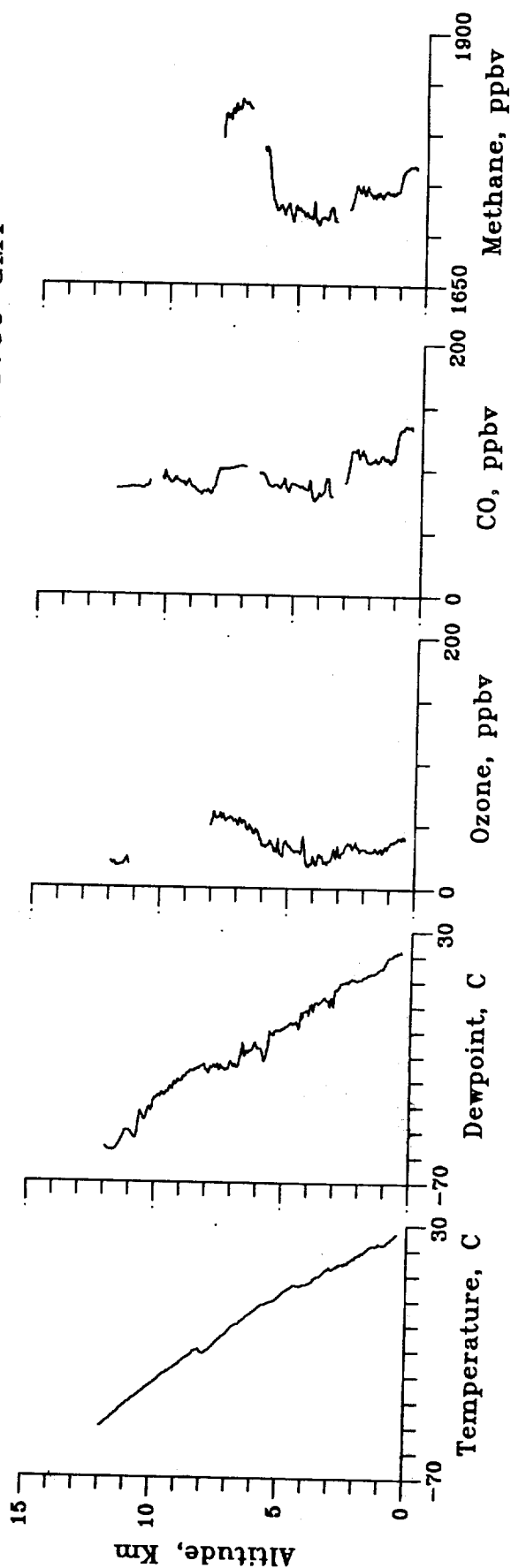


Figure A14.6



PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0945 GMT

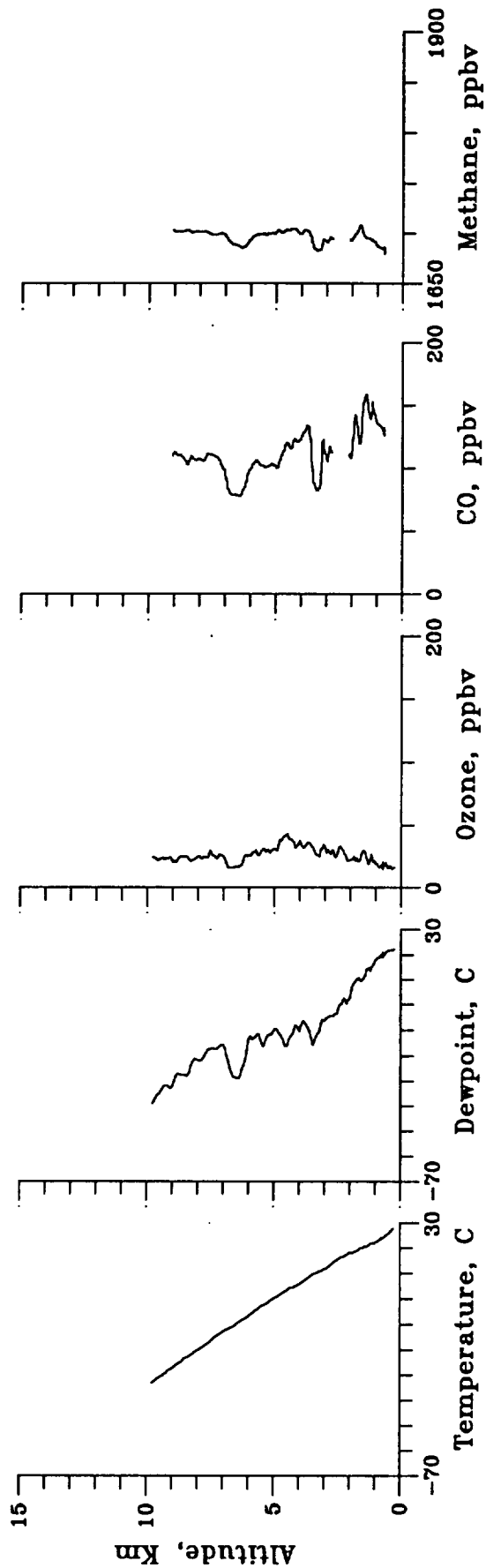


Figure A14.7



# PEM (A) PACIFIC MISSION: FLIGHT 15

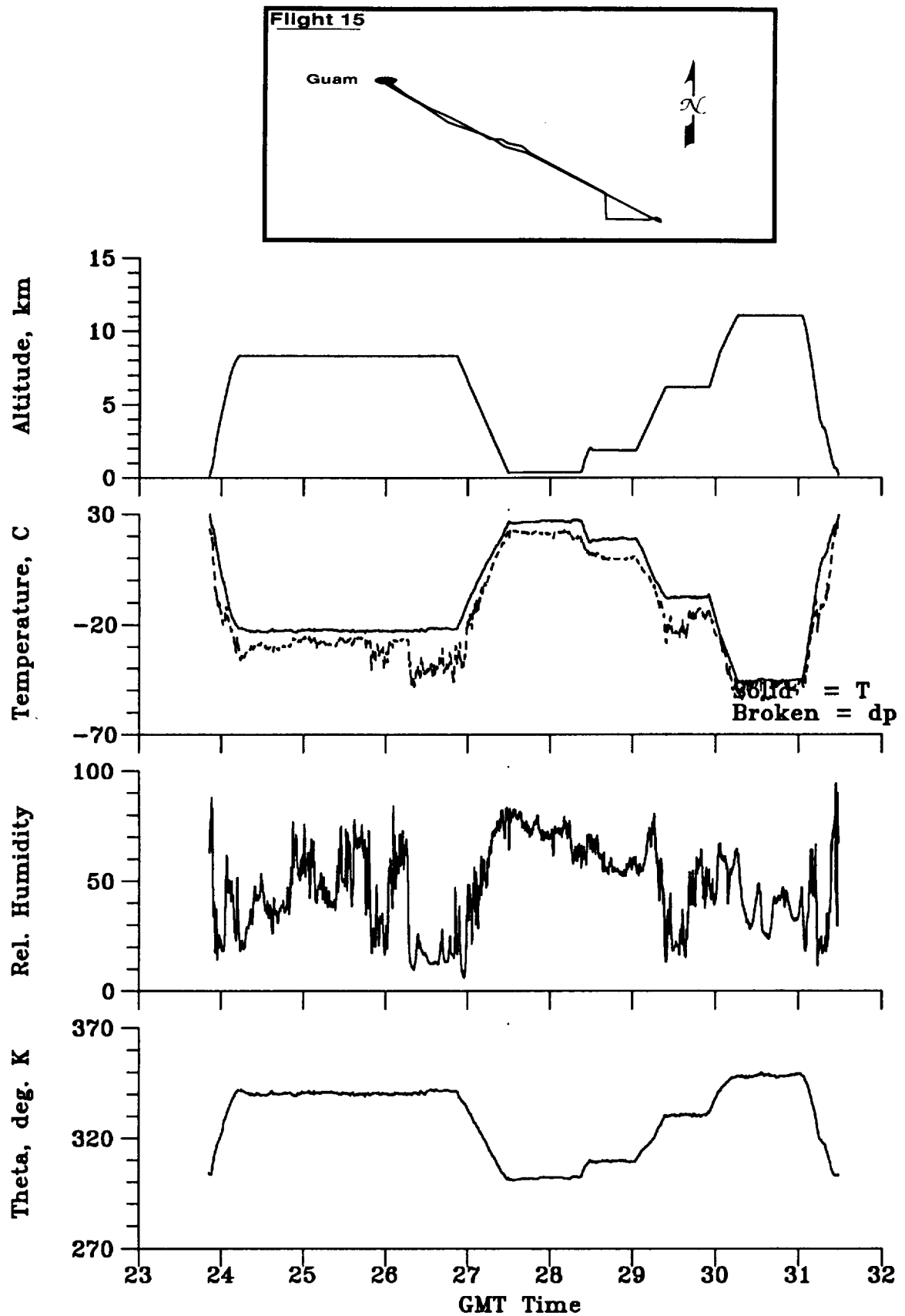


Figure A15.1

File 296

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# PEM (A) PACIFIC MISSION: FLIGHT 15

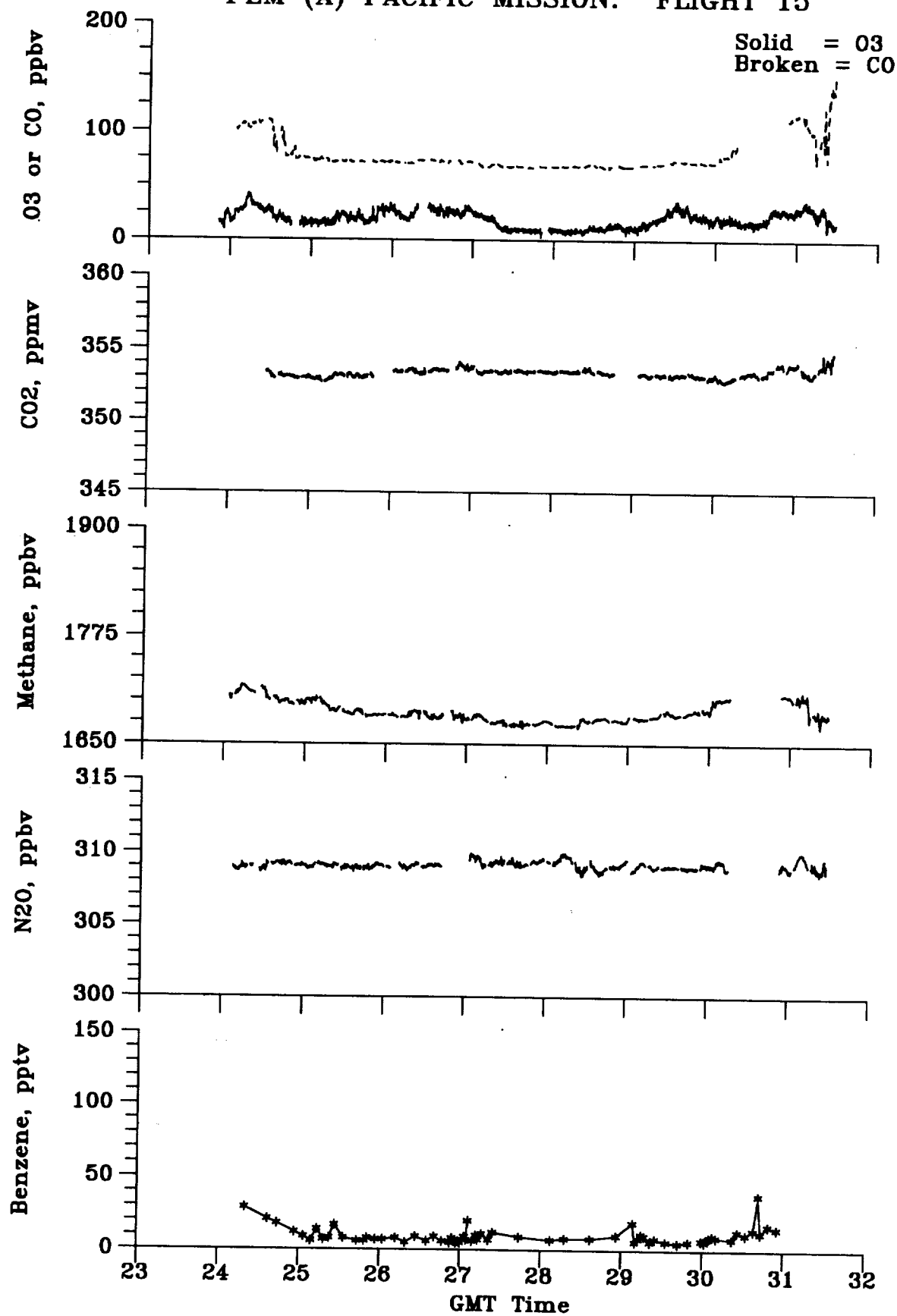


Figure A15.2

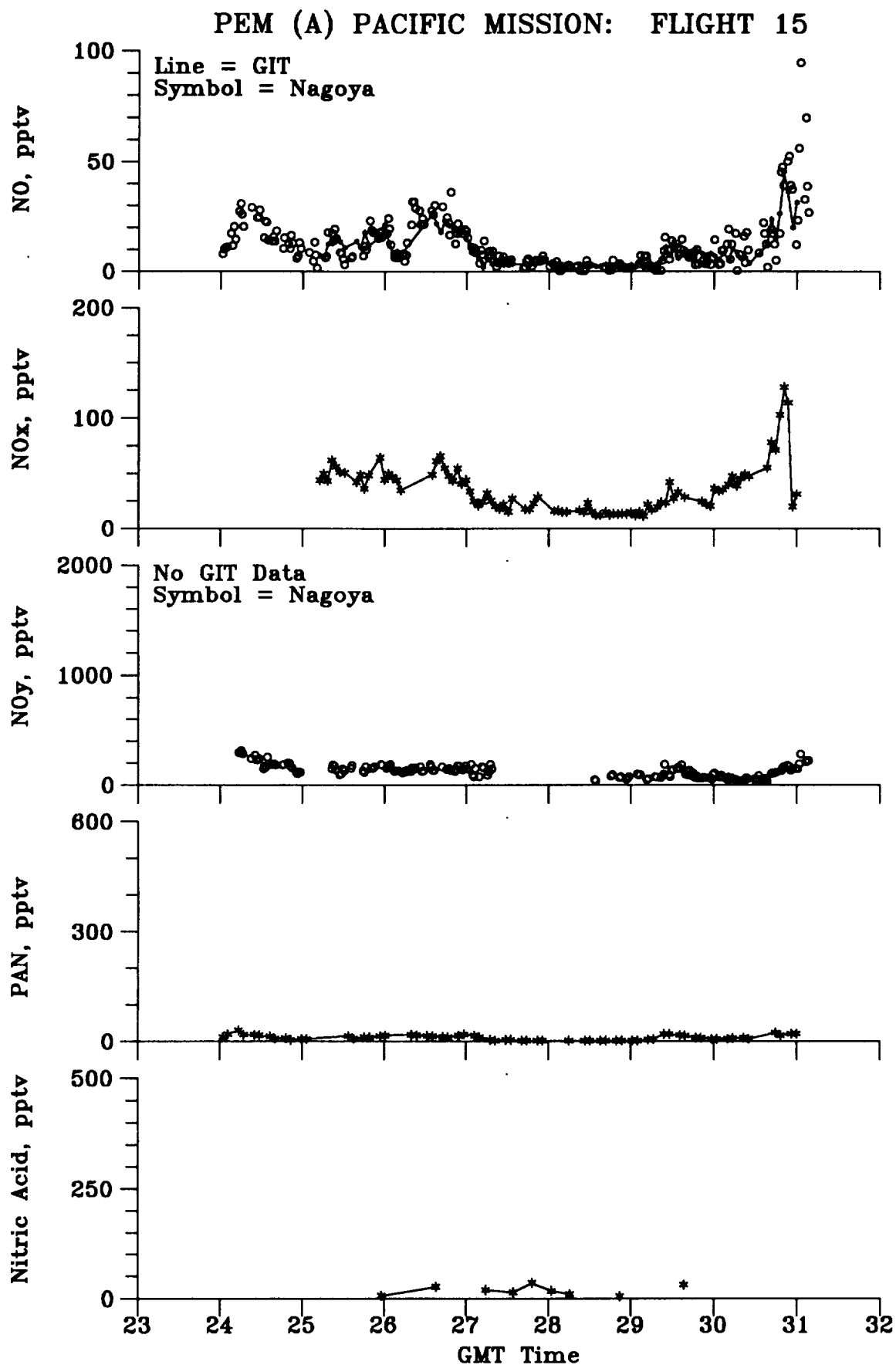


Figure A15.3

# PEM (A) PACIFIC MISSION: FLIGHT 15

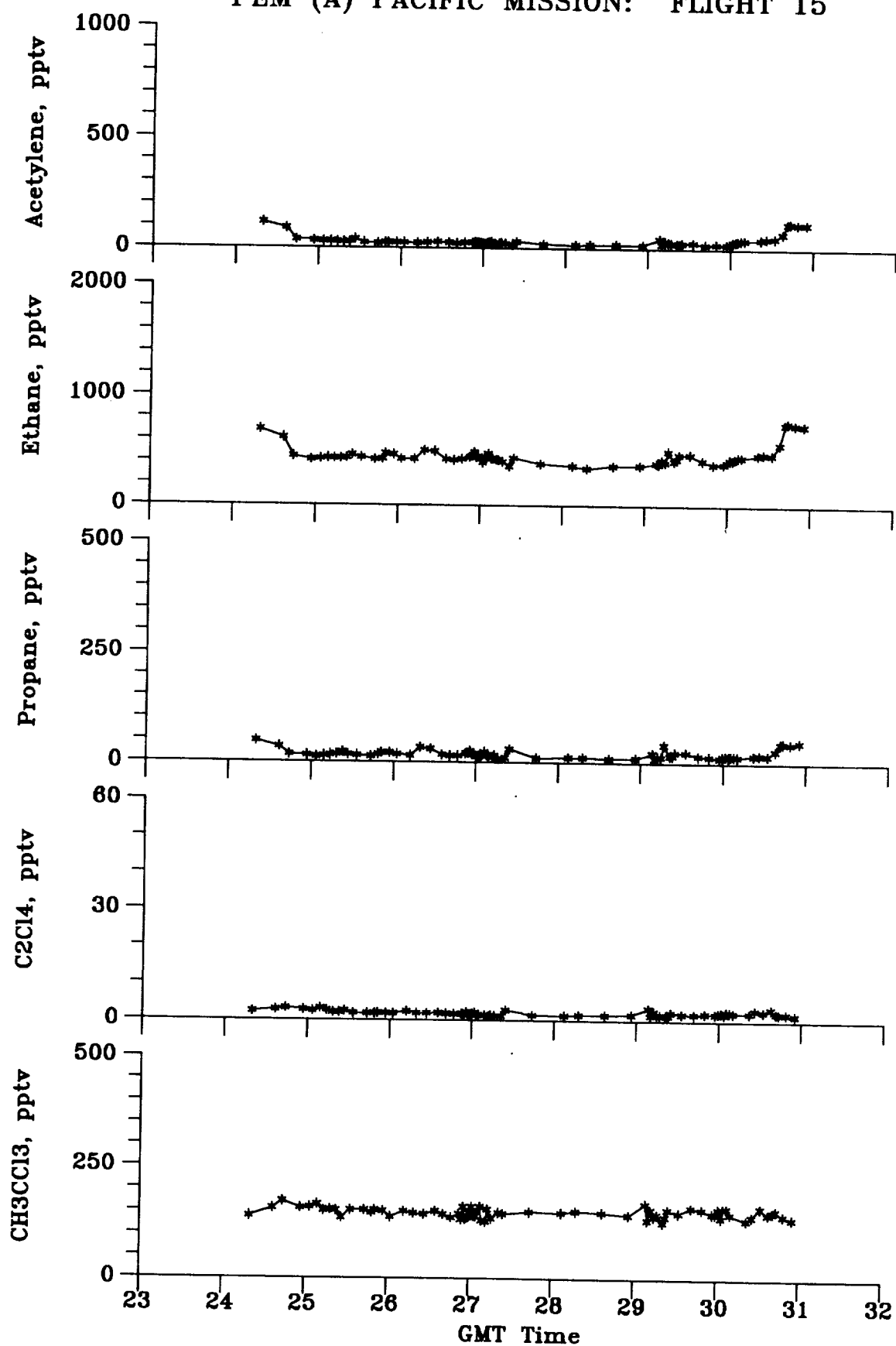


Figure A15.4

# PEM (A) PACIFIC MISSION: FLIGHT 15

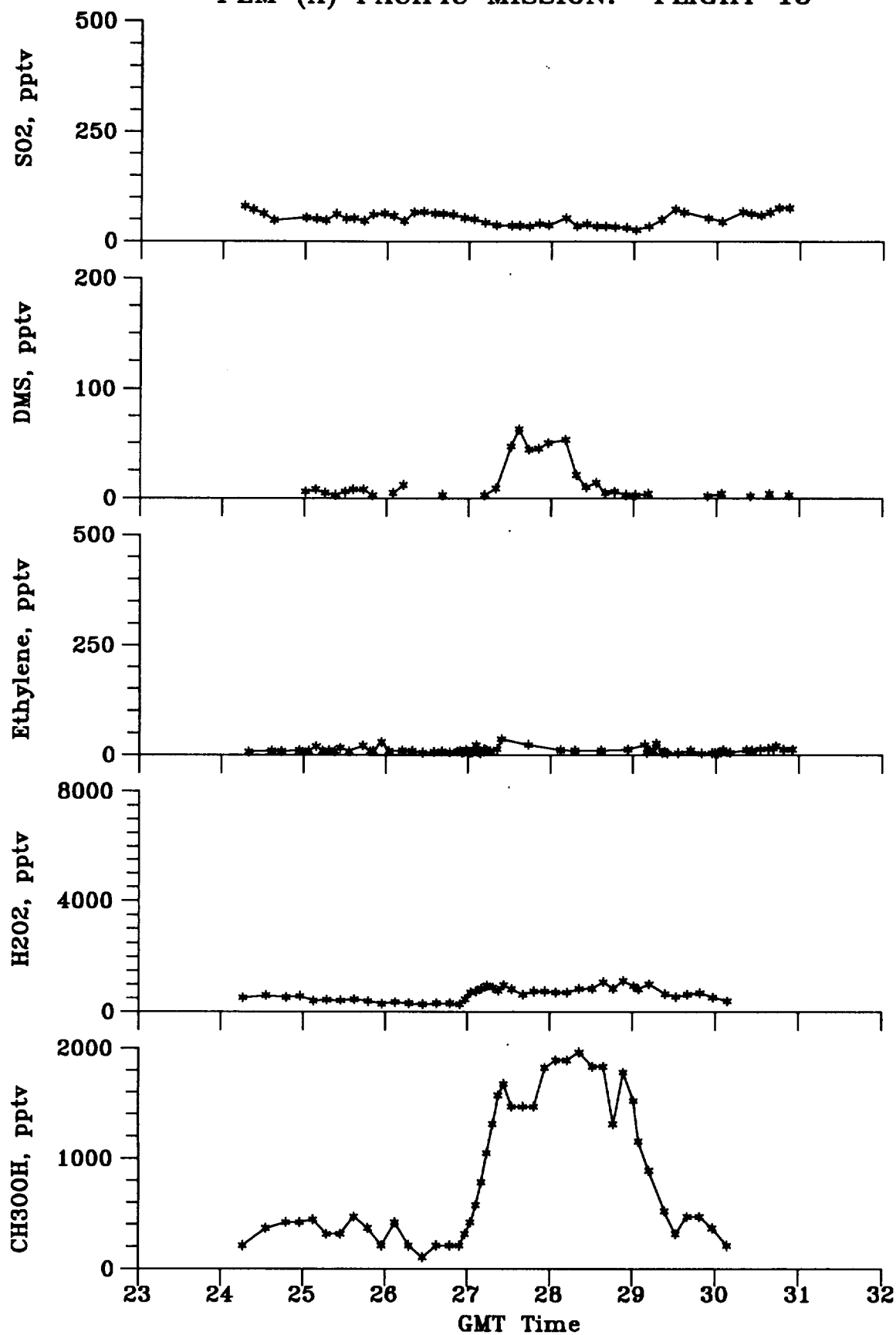
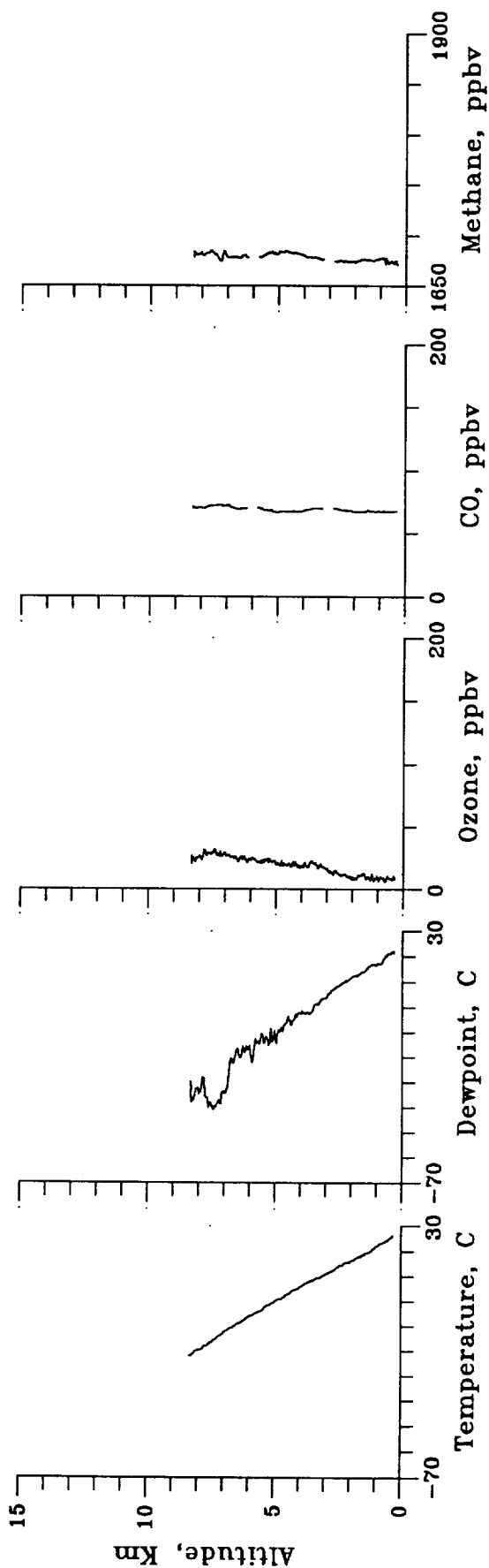


Figure A15.5

PEM (A) PACIFIC MISSION: FLIGHT 15 PROFILE AT 0315 GMT



PEM (A) PACIFIC MISSION: FLIGHT 15 PROFILE AT 0715 GMT

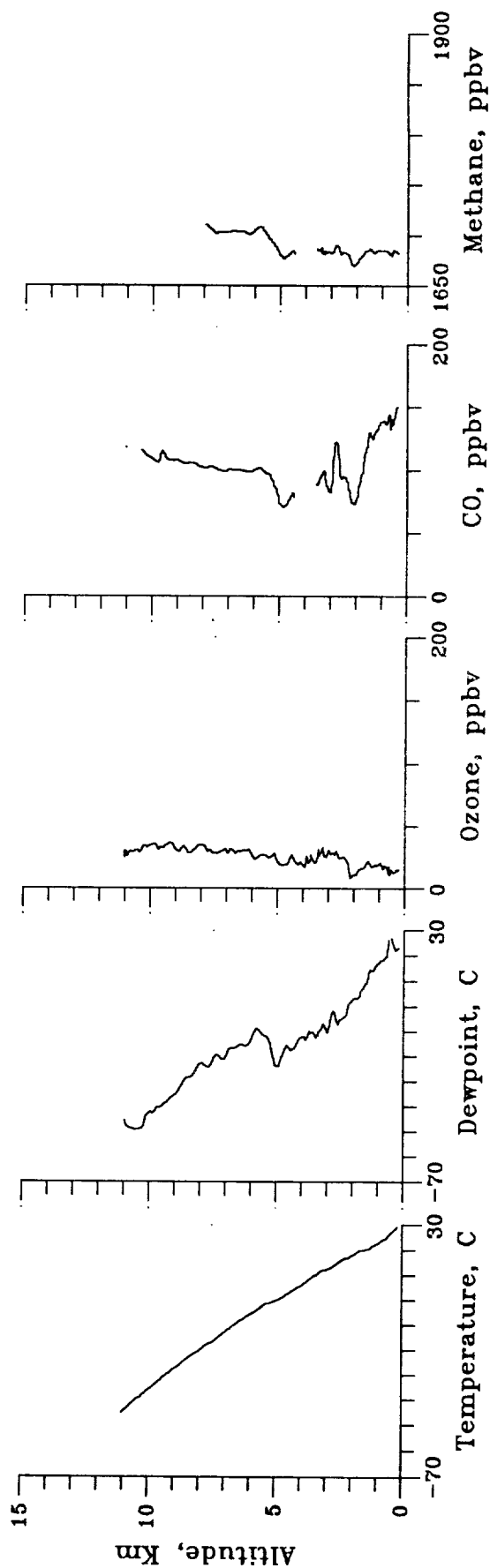


Figure A15.6



# PEM (A) PACIFIC MISSION: FLIGHT 16

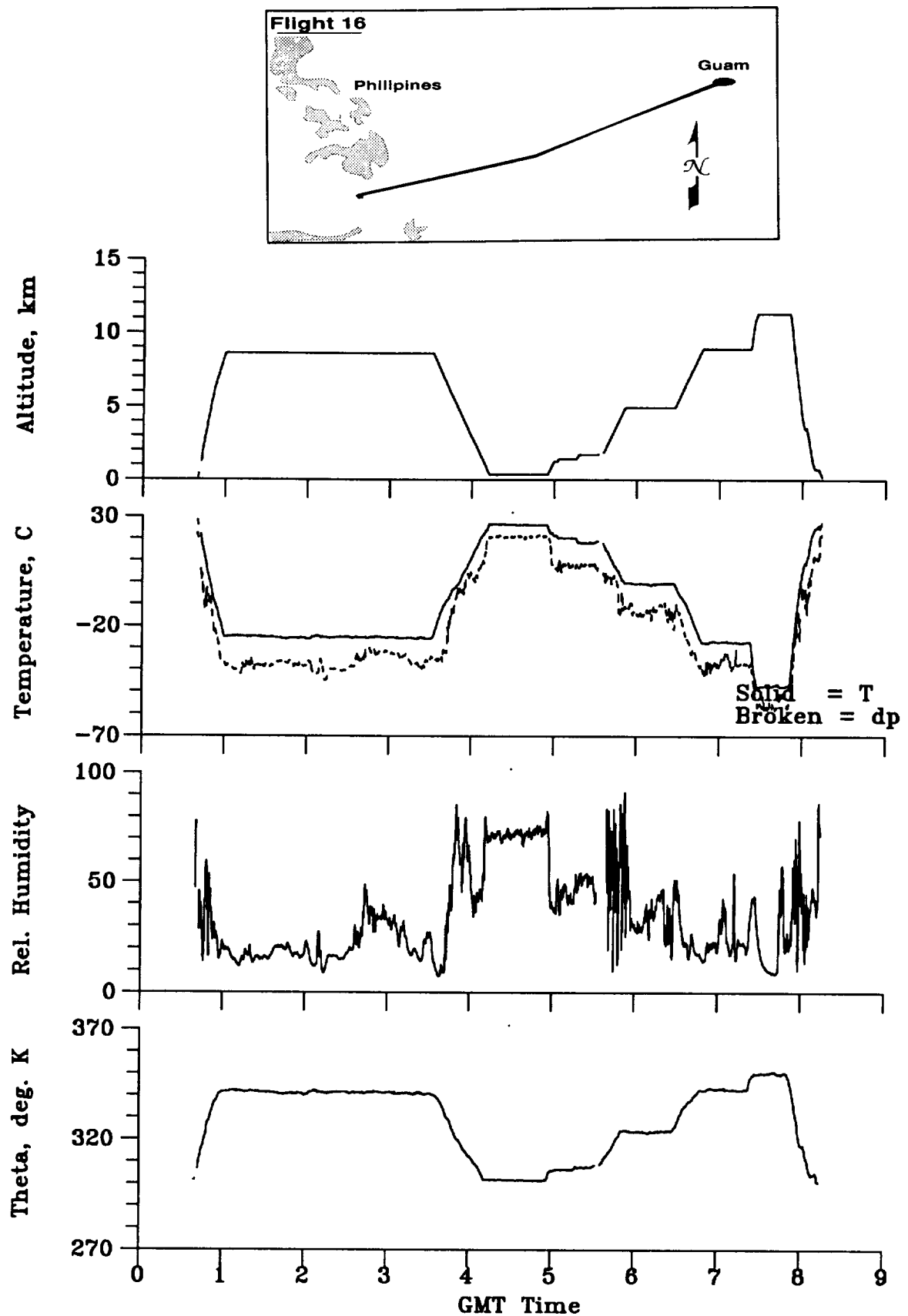


Figure A16.1

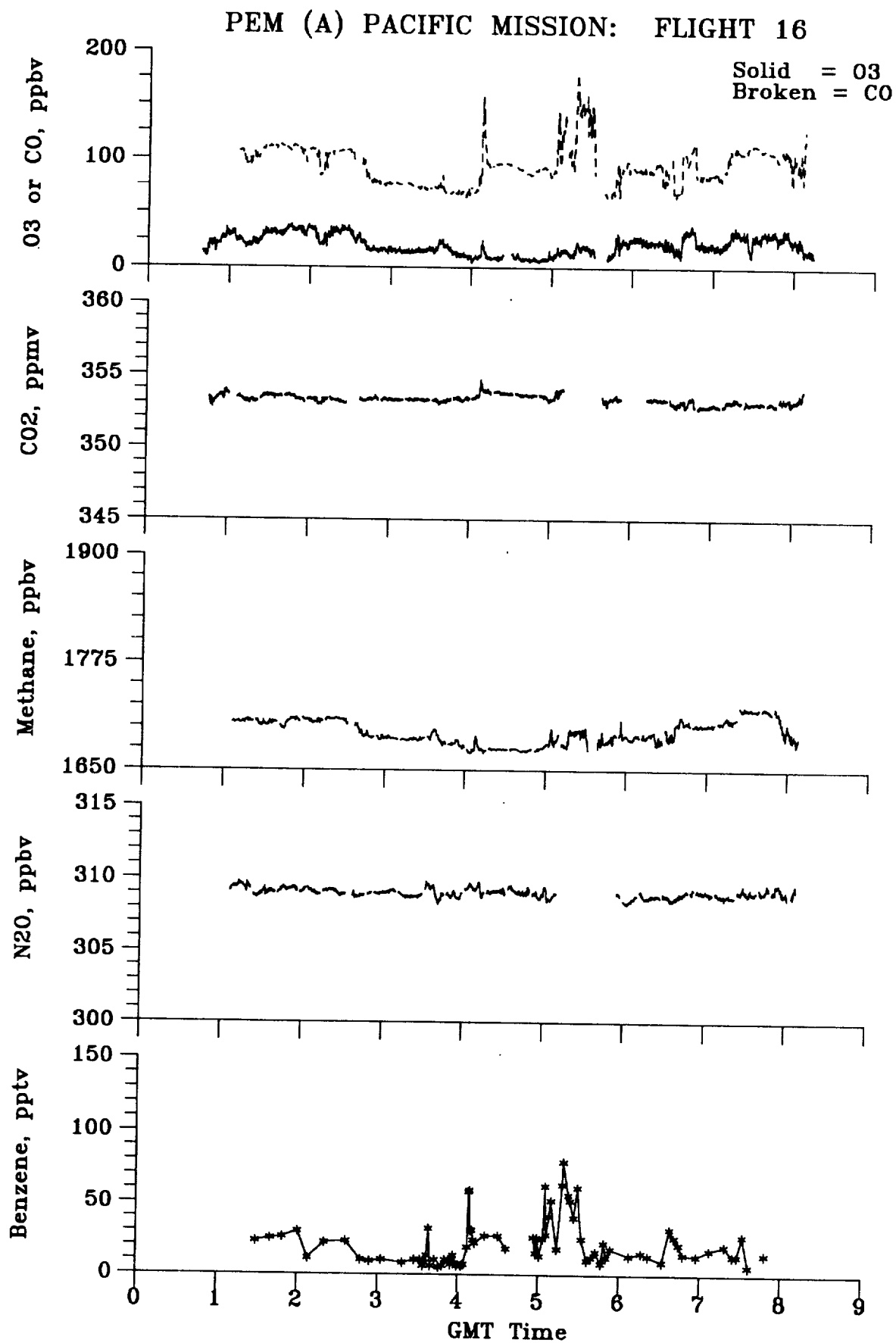


Figure A16.2

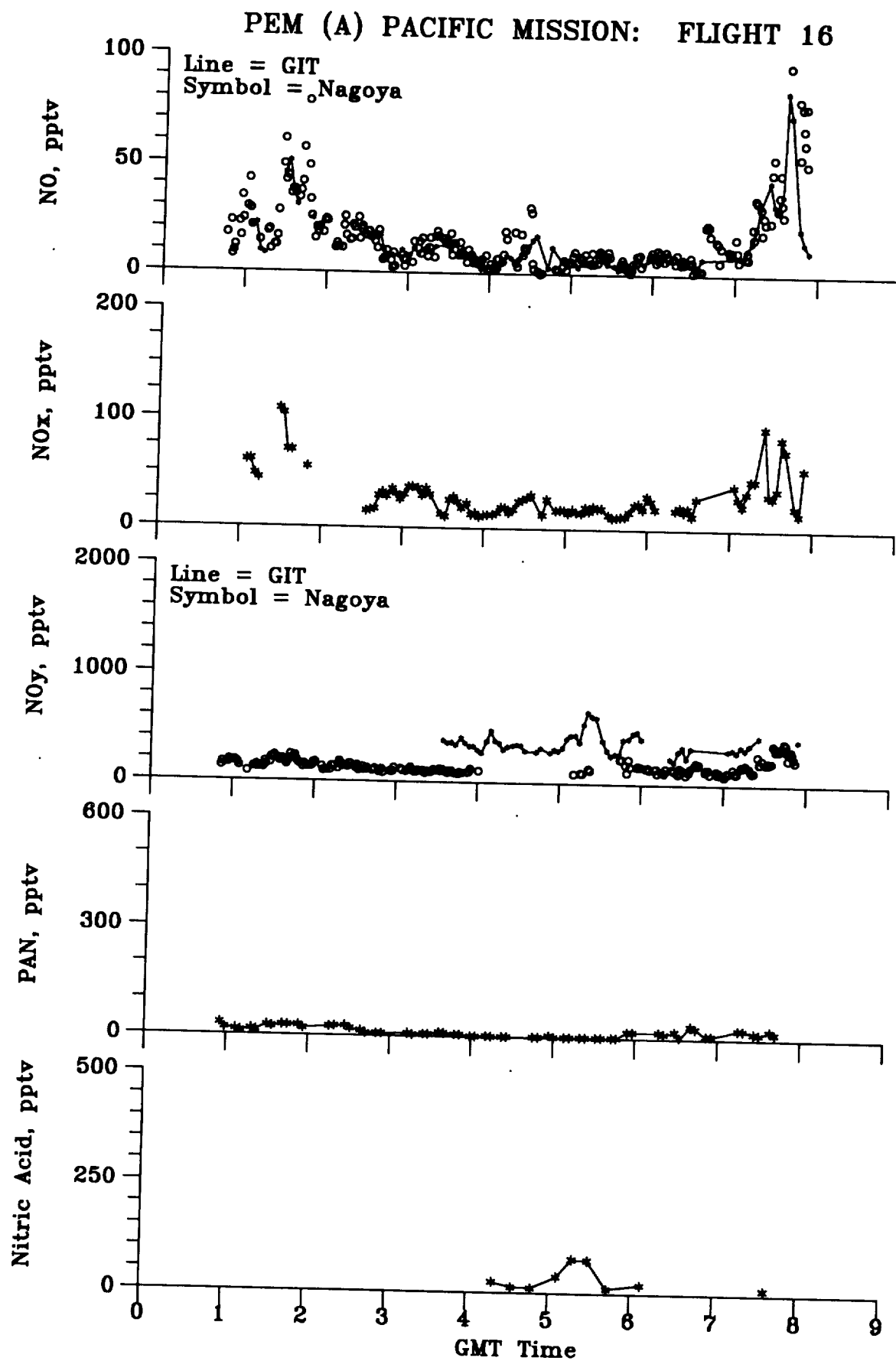


Figure A16.3

PEM (A) PACIFIC MISSION: FLIGHT 16

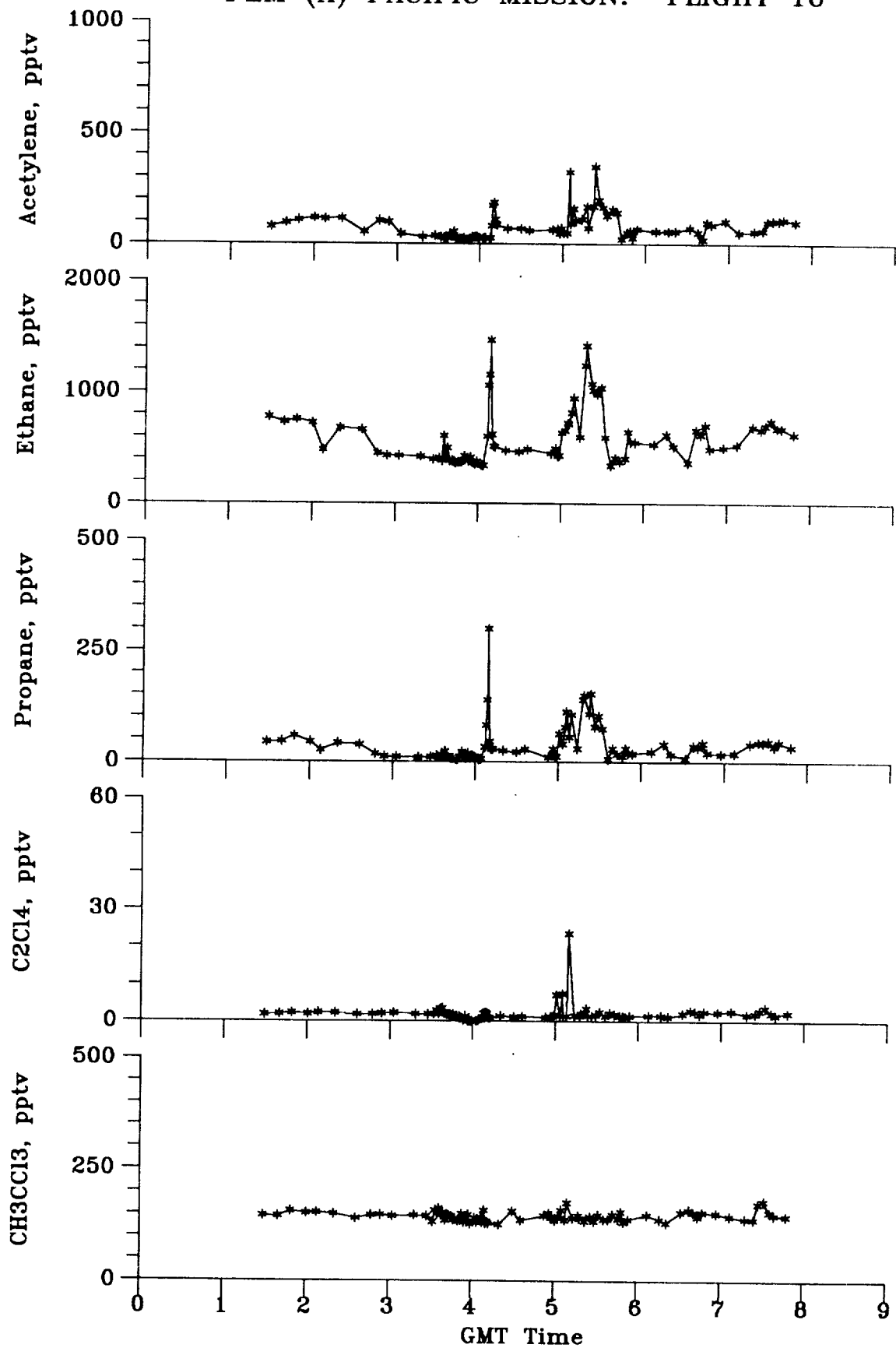


Figure A16.4

# PEM (A) PACIFIC MISSION: FLIGHT 16

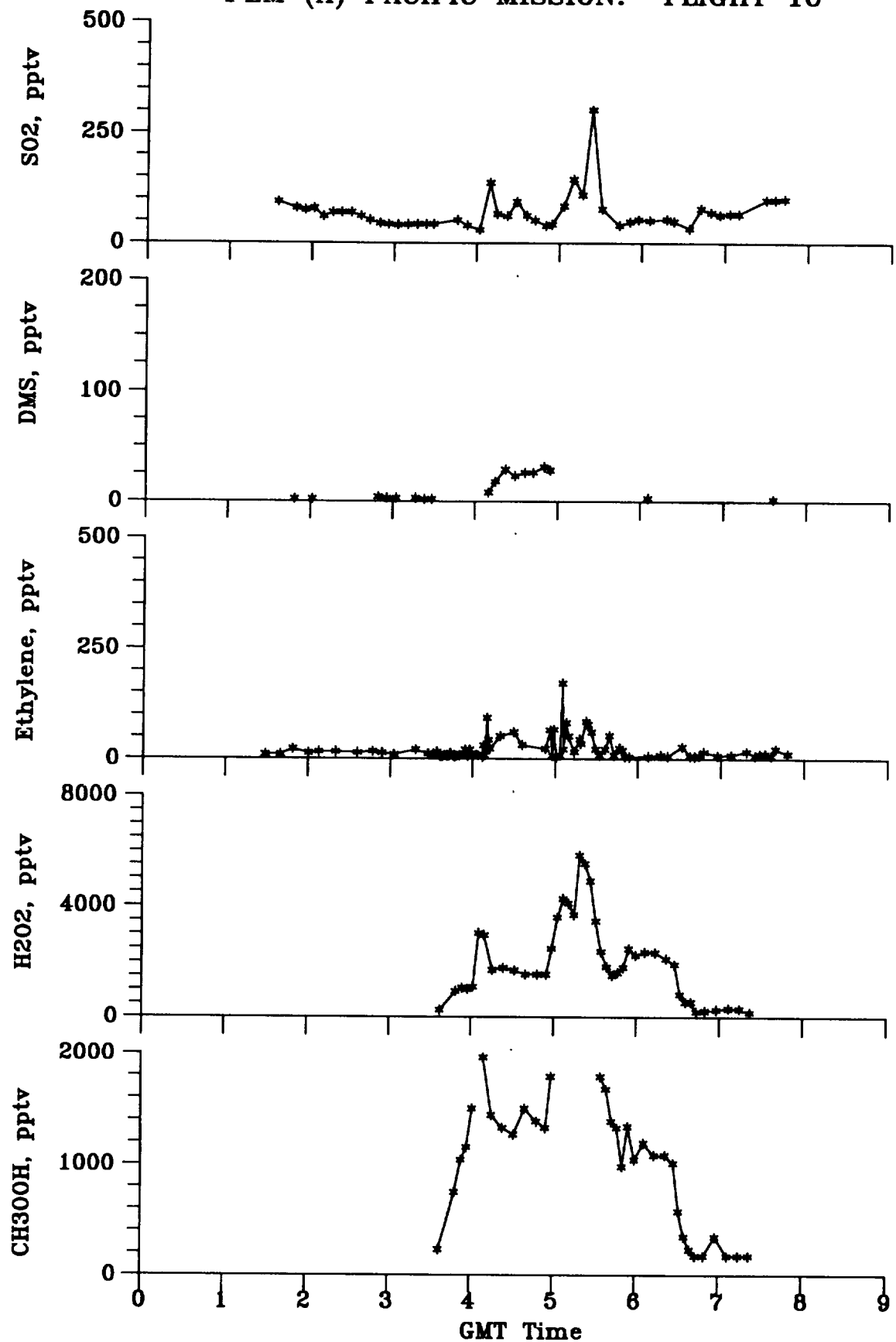
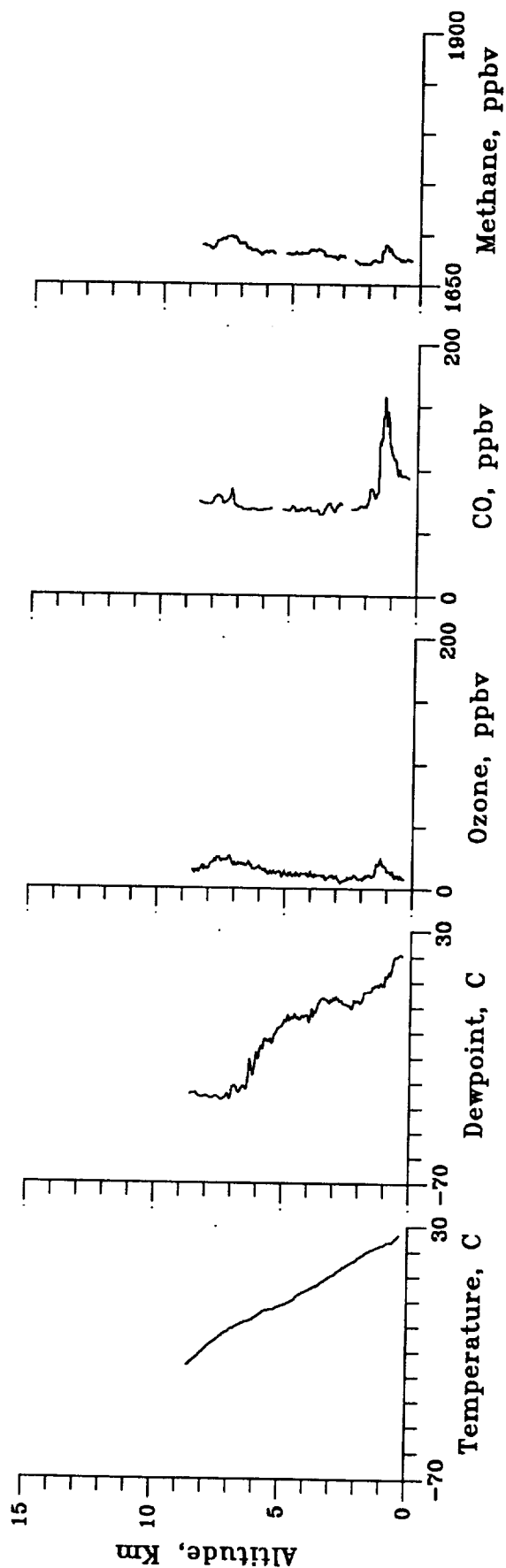


Figure A16.5

PEM (A) PACIFIC MISSION: FLIGHT 16 PROFILE AT 0400 GMT



PEM (A) PACIFIC MISSION: FLIGHT 16 PROFILE AT 0800 GMT

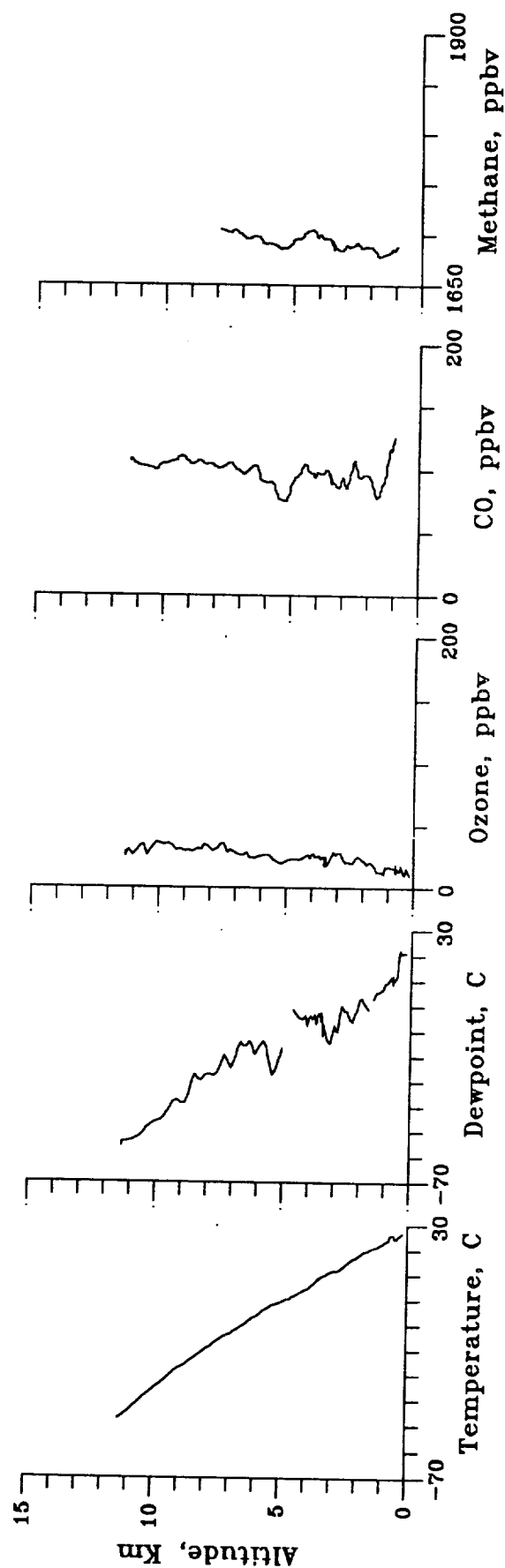


Figure A16.8

# PEM (A) PACIFIC MISSION: FLIGHT 17

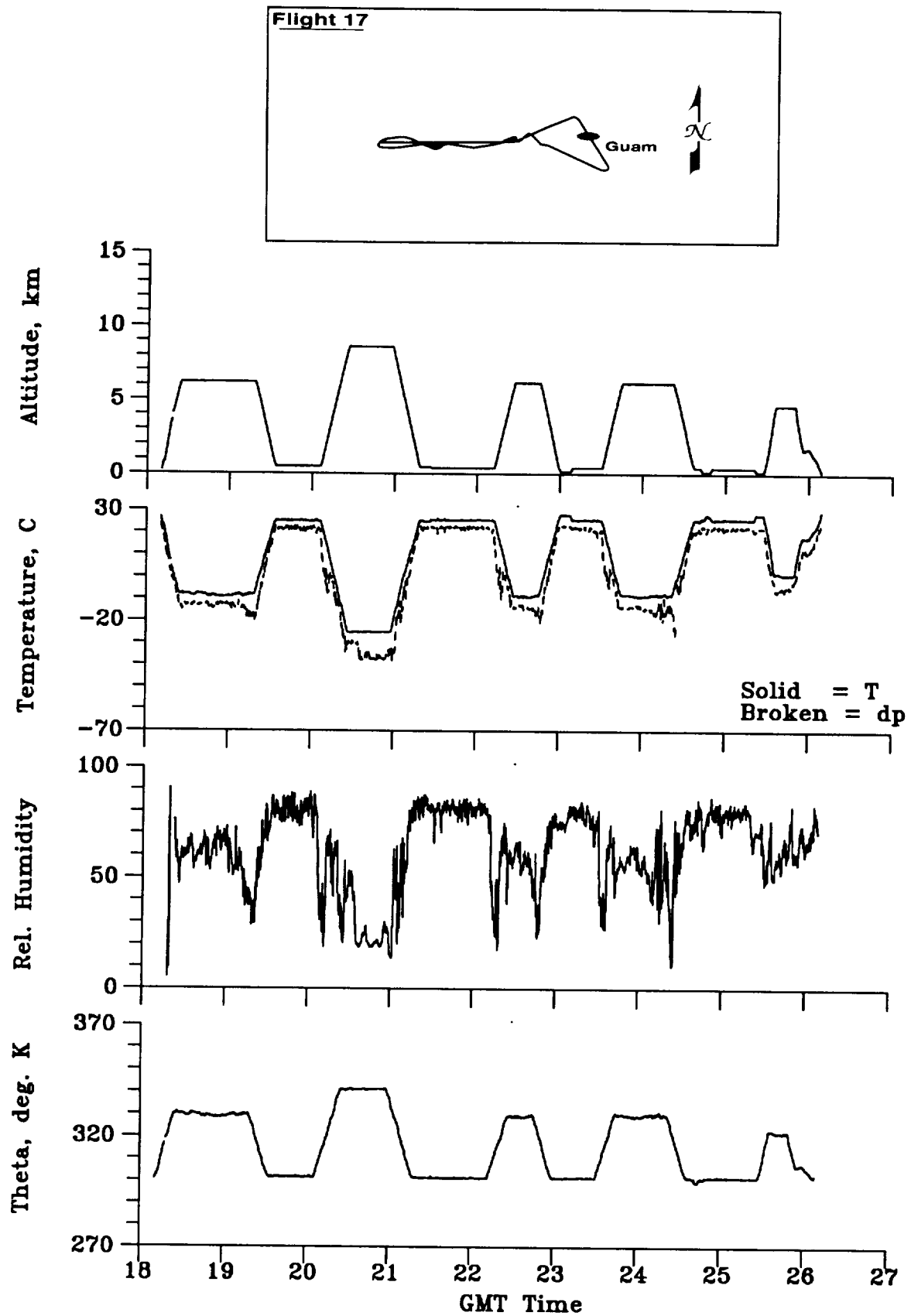


Figure A17.1

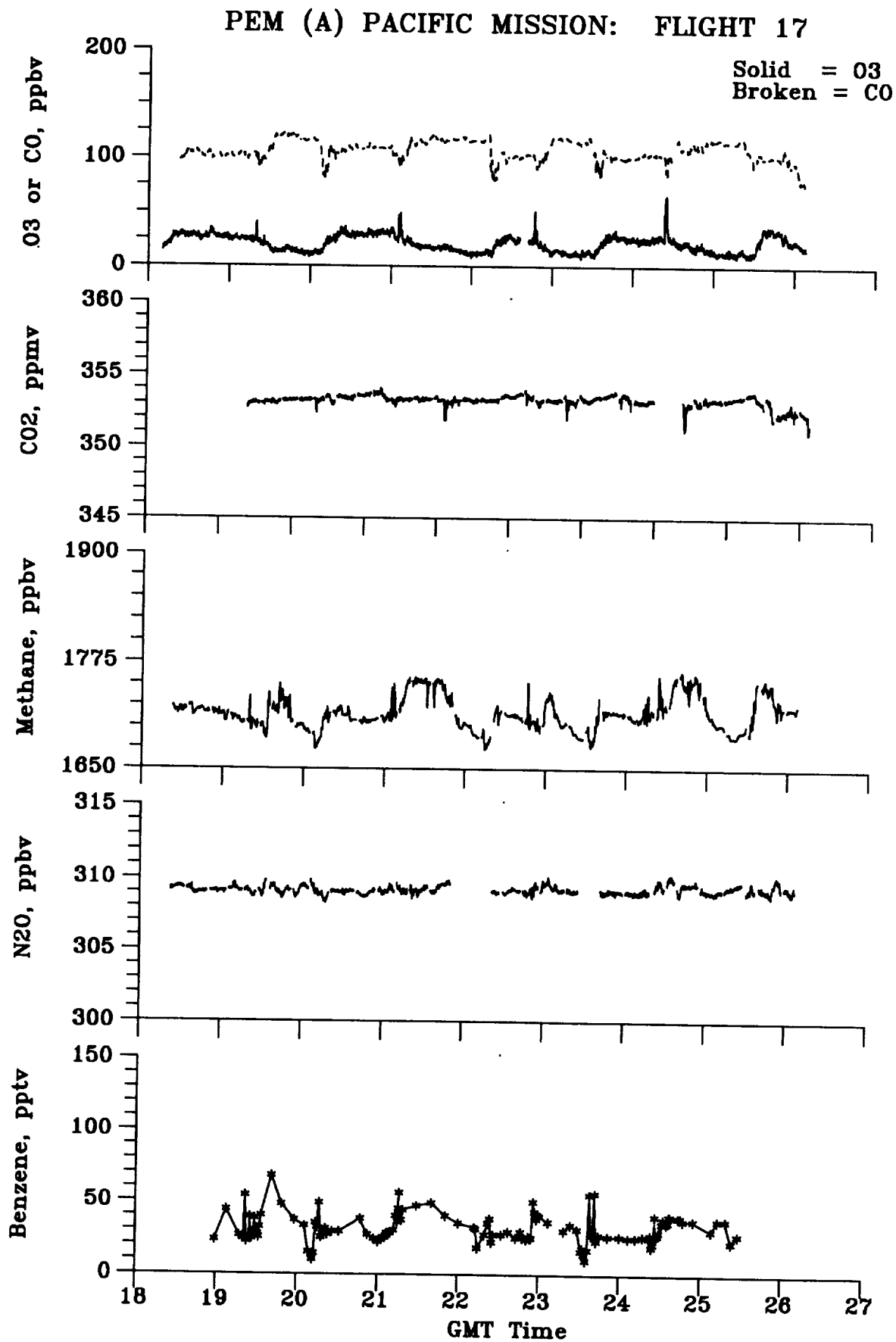


Figure A17.2



# PEM (A) PACIFIC MISSION: FLIGHT 17

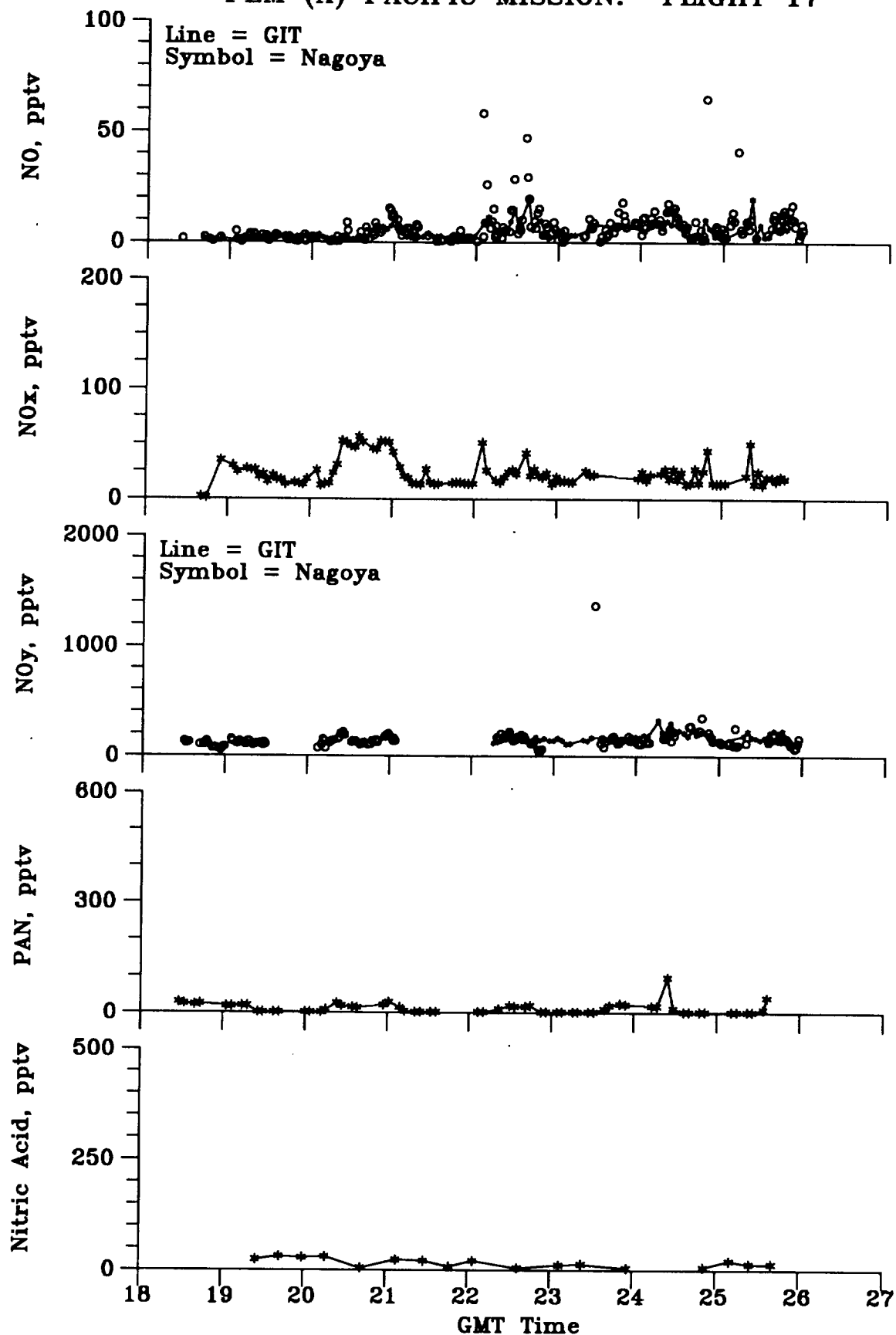


Figure A17.3

PEM (A) PACIFIC MISSION: FLIGHT 17

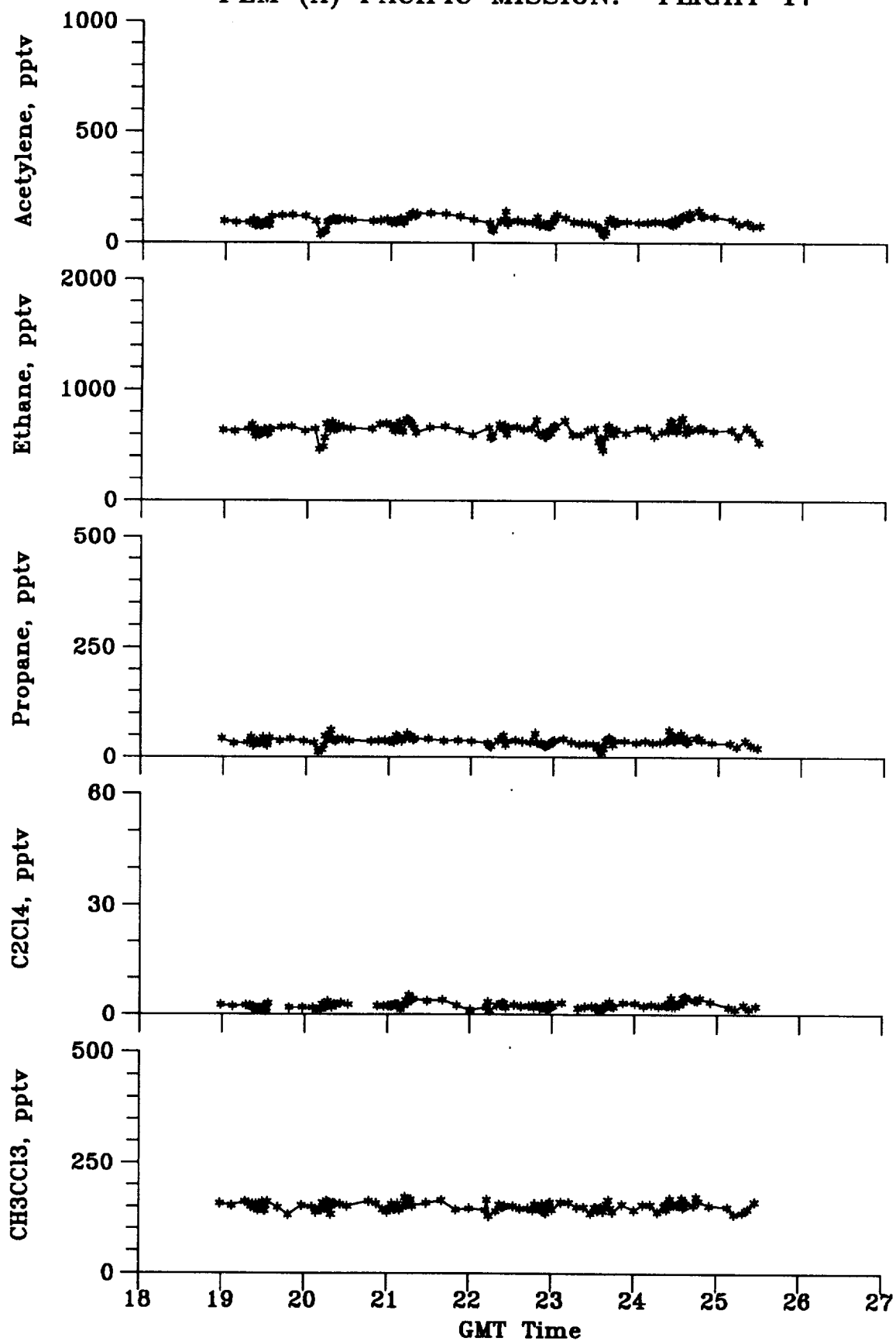


Figure A17.4

# PEM (A) PACIFIC MISSION: FLIGHT 17

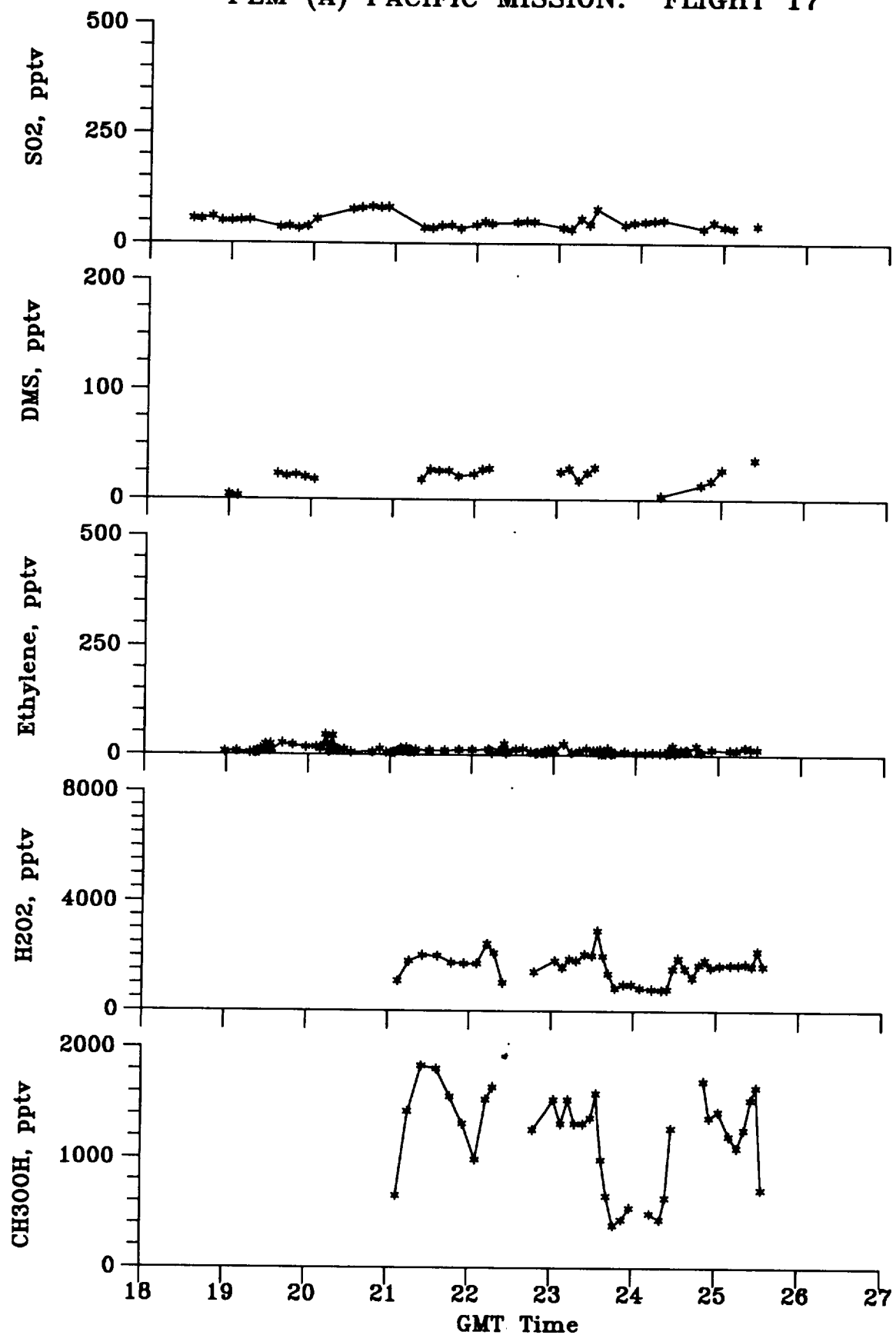
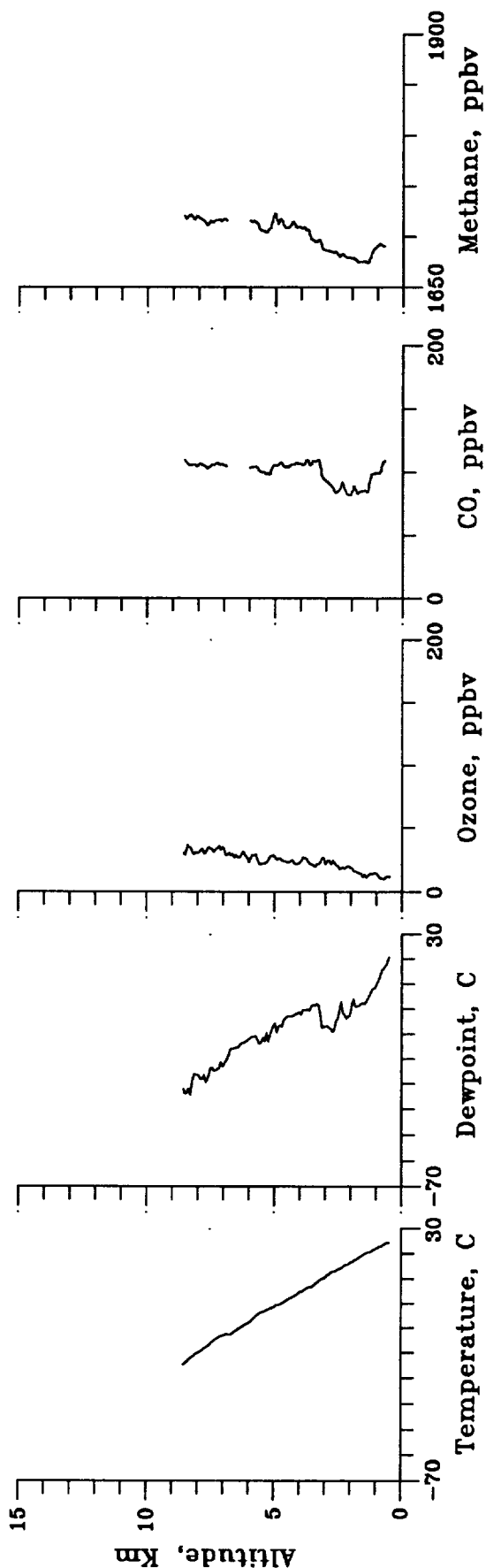


Figure A17.5

PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 2015 GMT



PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 2300 GMT

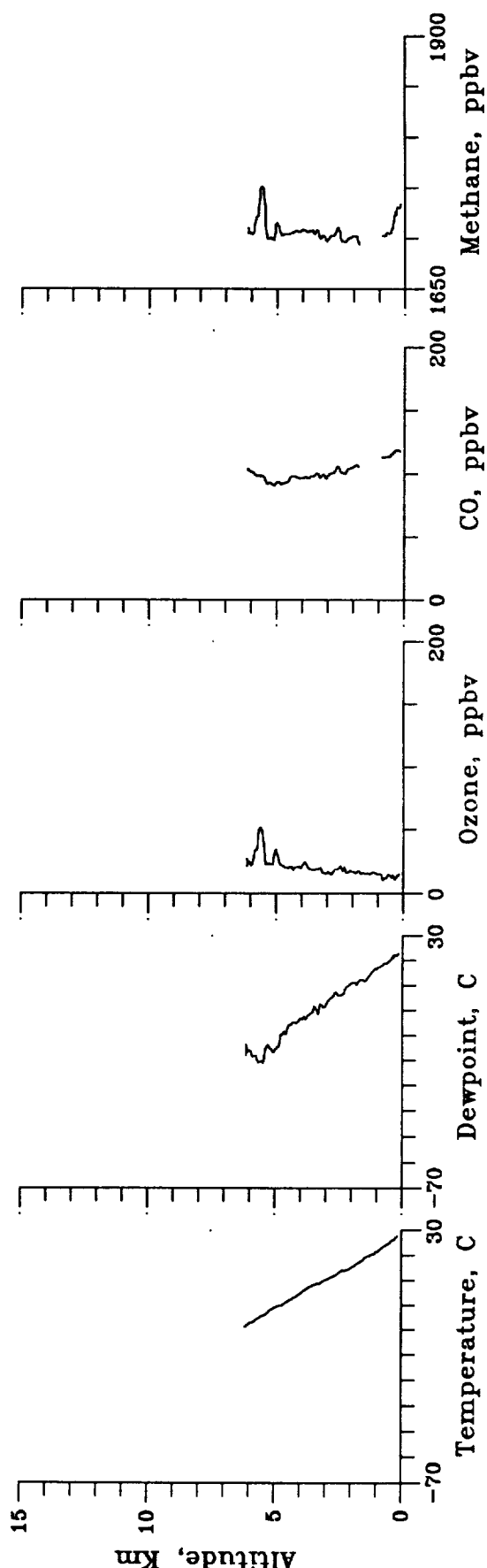


Figure A17.6

PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 0200 GMT

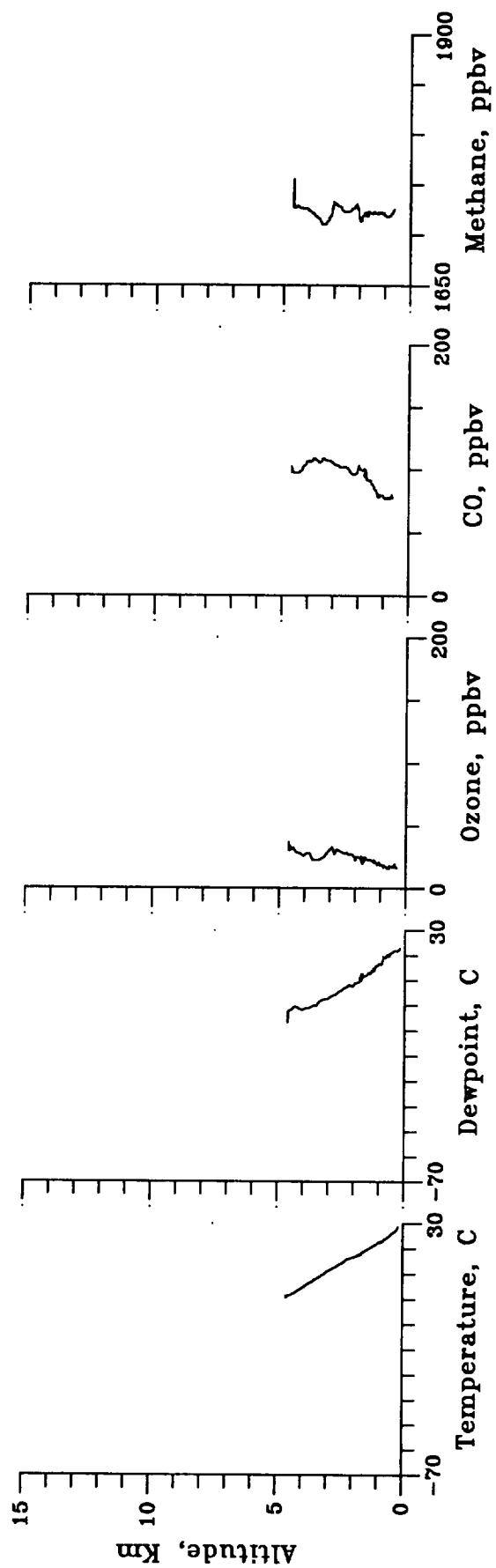


Figure A17.7



# PEM (A) PACIFIC MISSION: FLIGHT 18

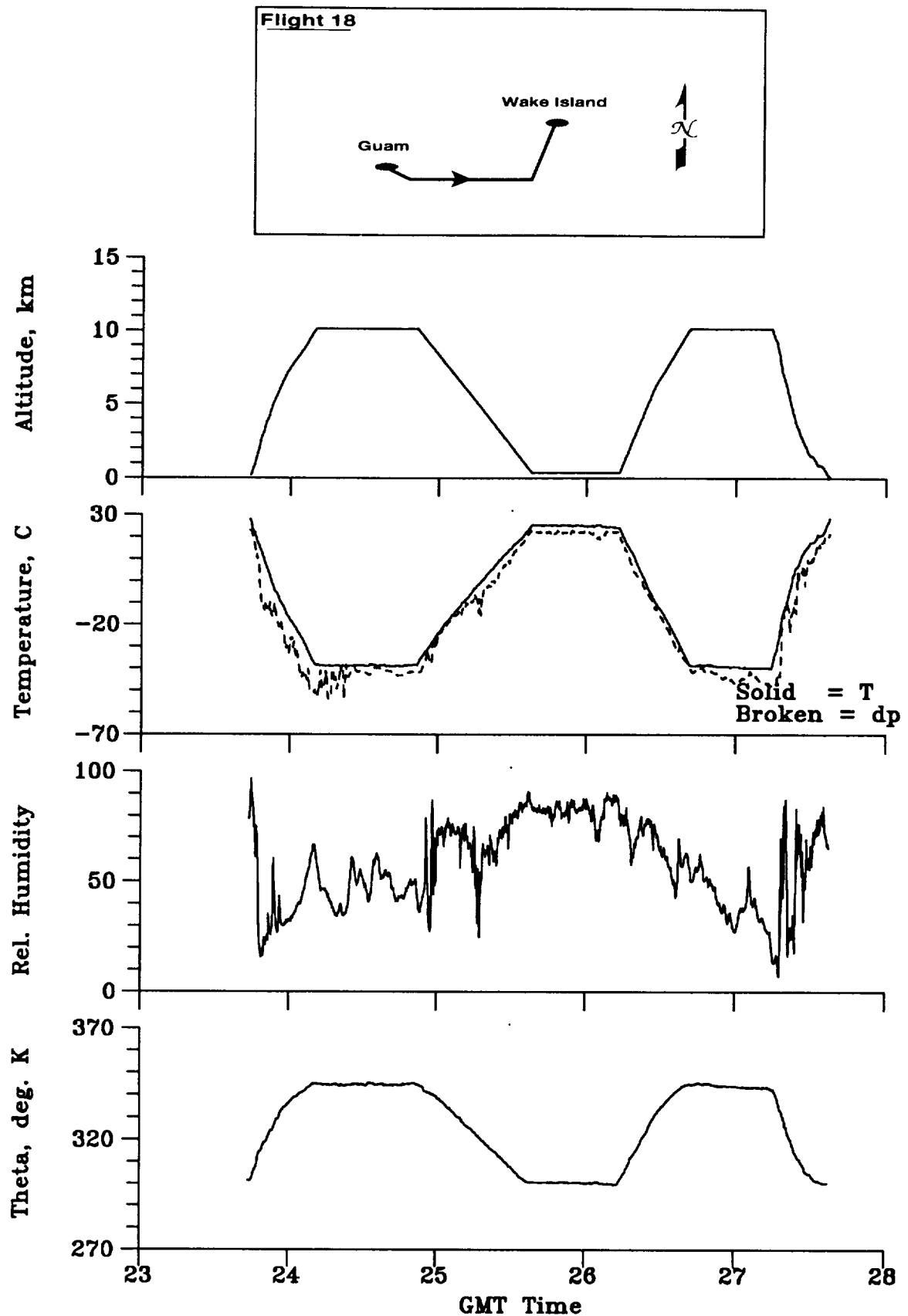


Figure A18.1

# PEM (A) PACIFIC MISSION: FLIGHT 18

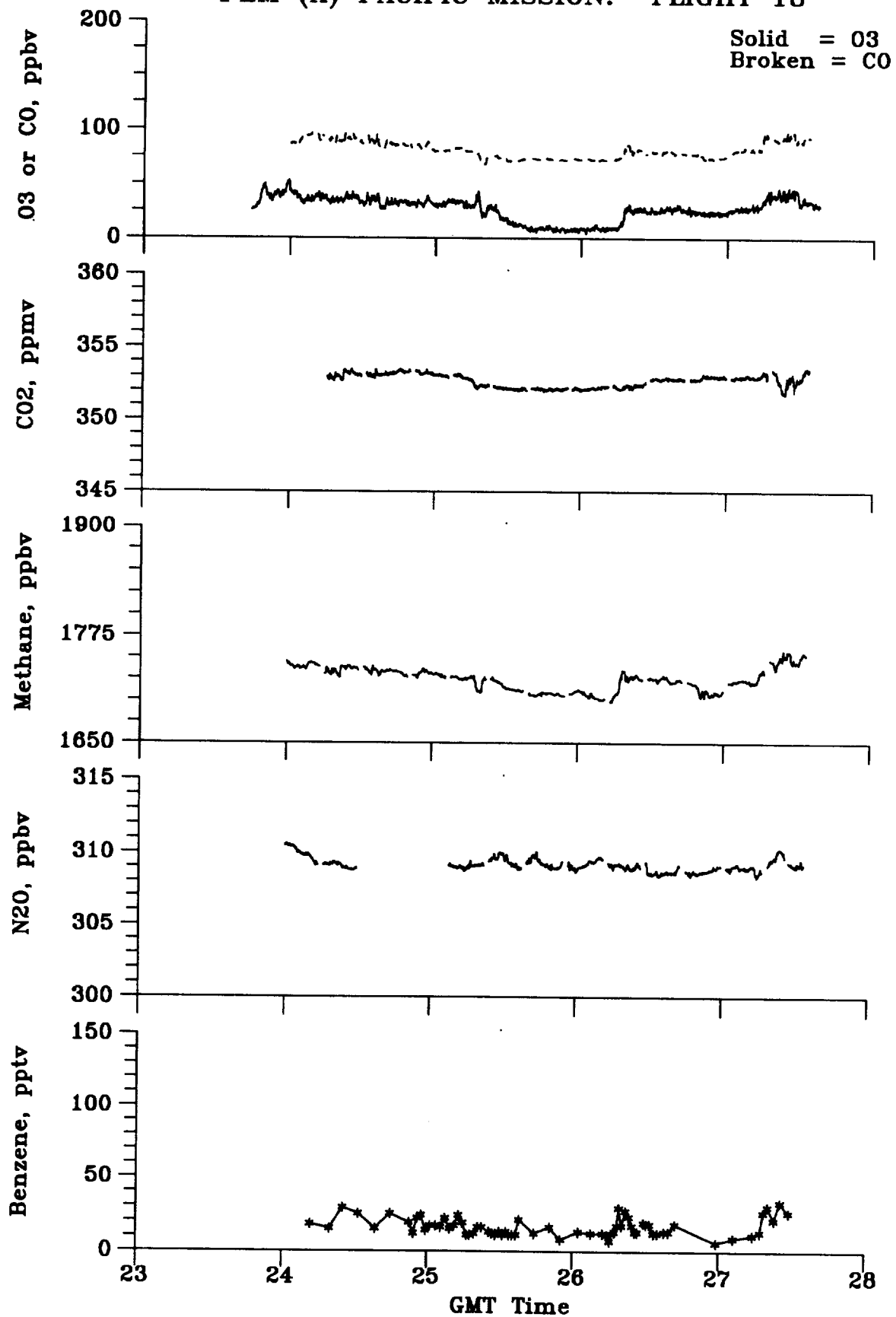


Figure A18.2



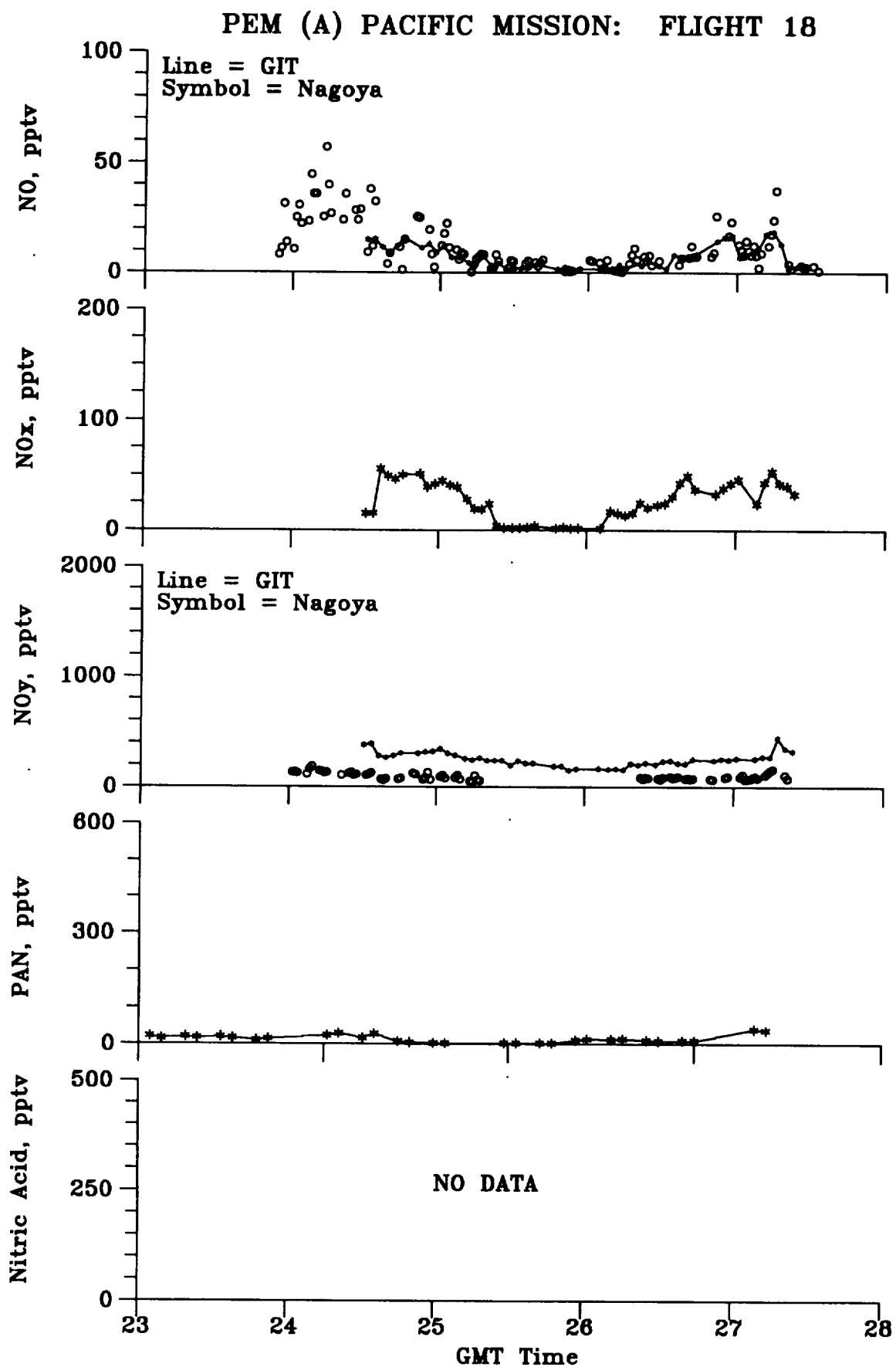


Figure A18.3

# PEM (A) PACIFIC MISSION: FLIGHT 18

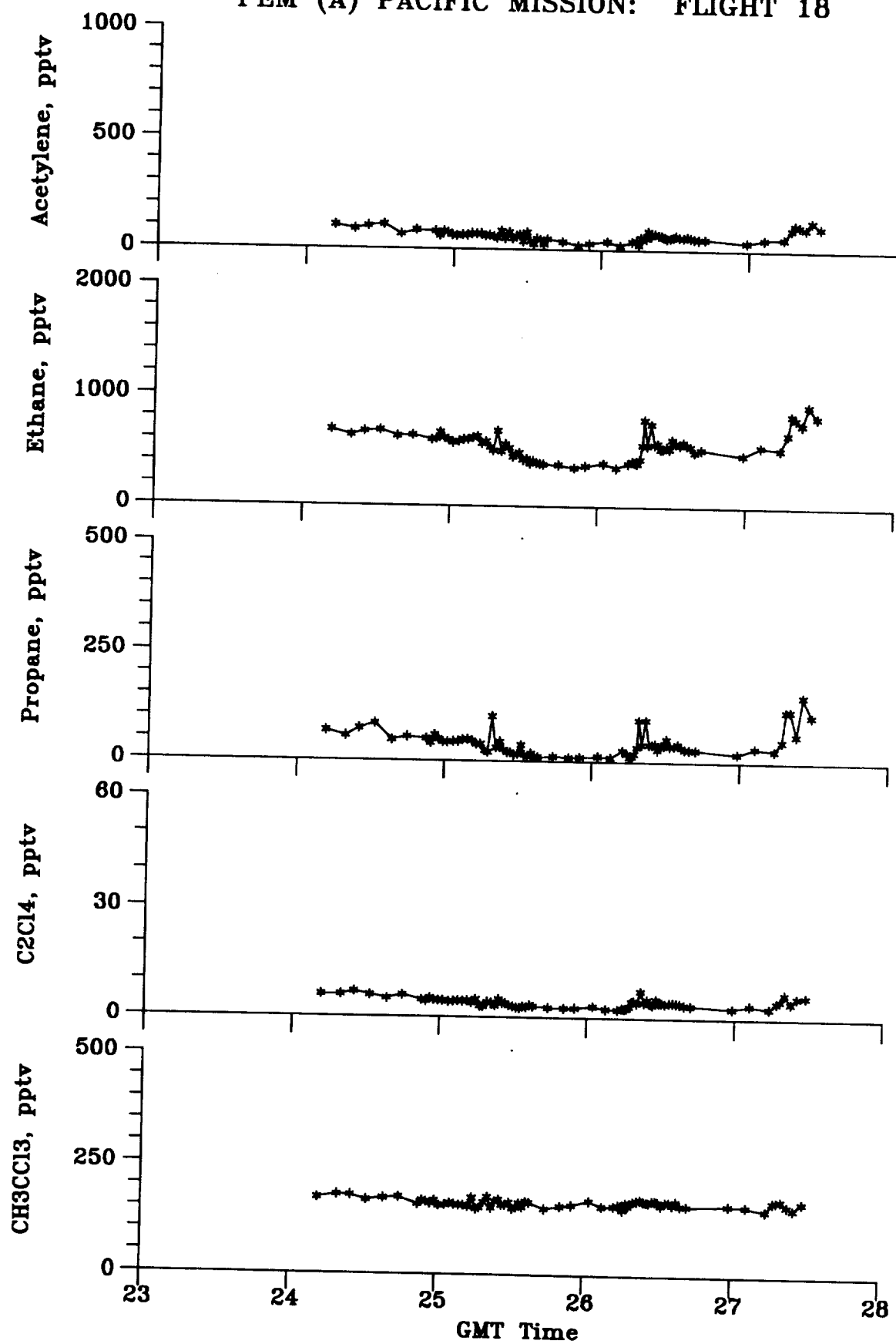


Figure A18.4

# PEM (A) PACIFIC MISSION: FLIGHT 18

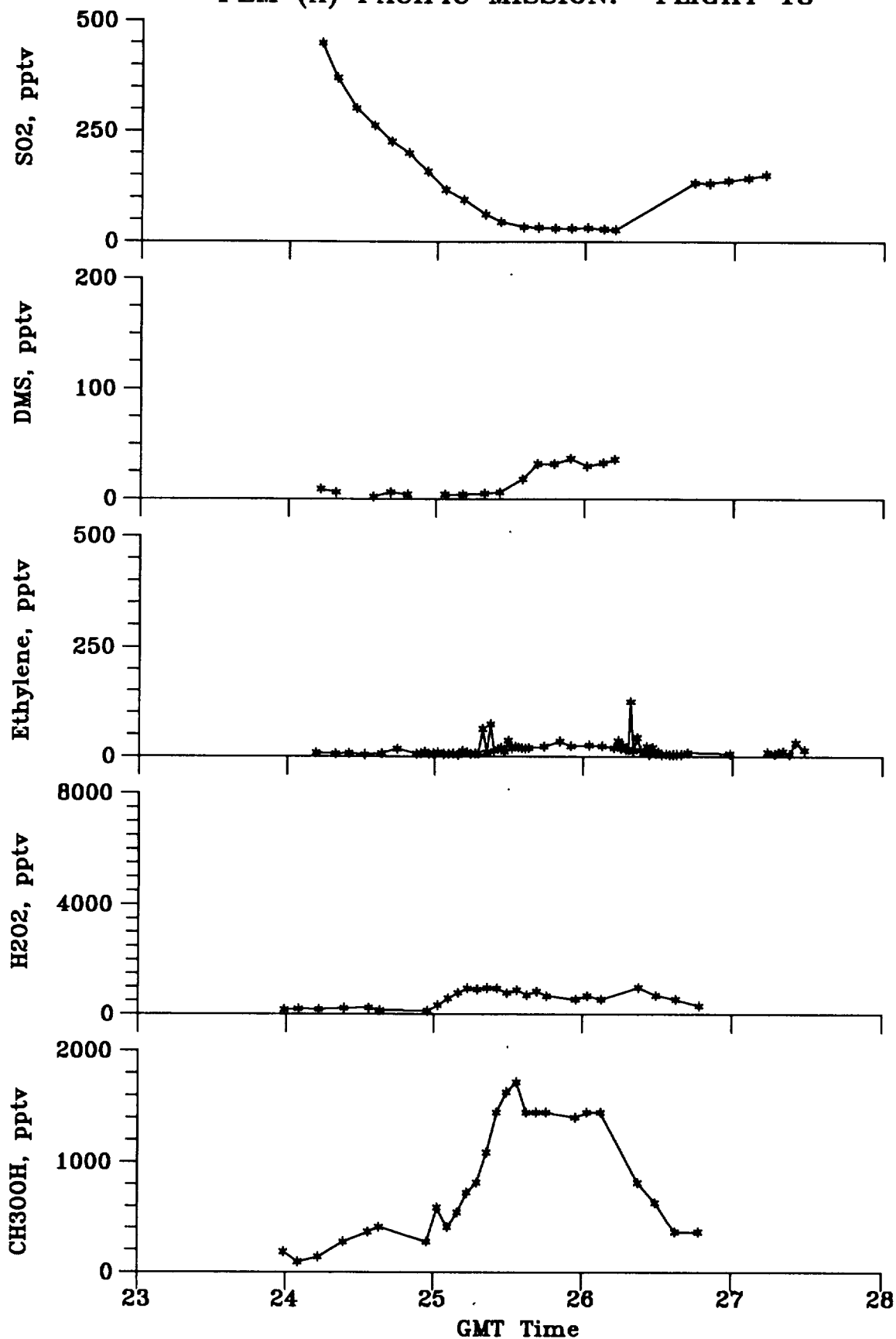
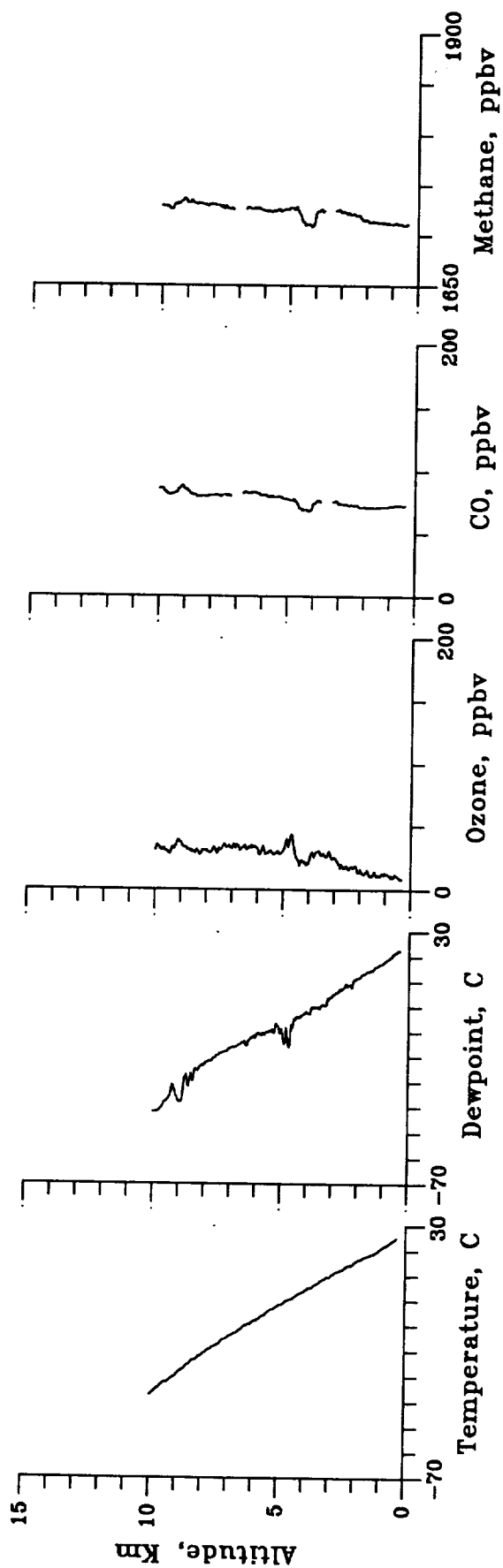


Figure A18.5

PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0115 GMT



PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0230 GMT

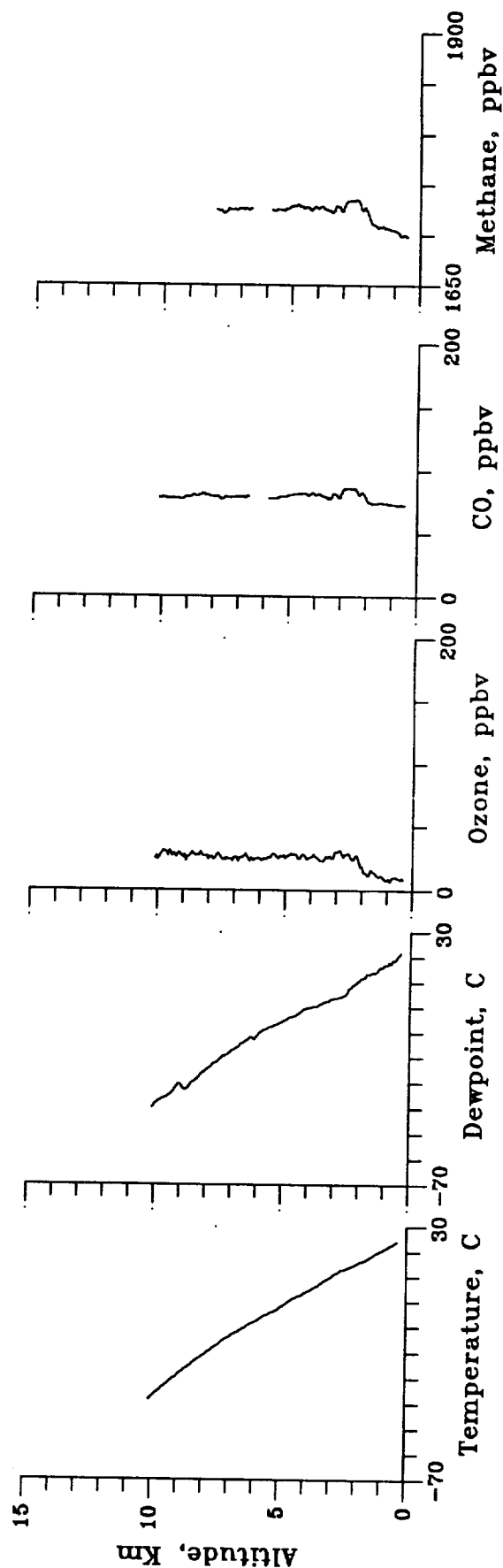


Figure A18.6

PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0330 GMT

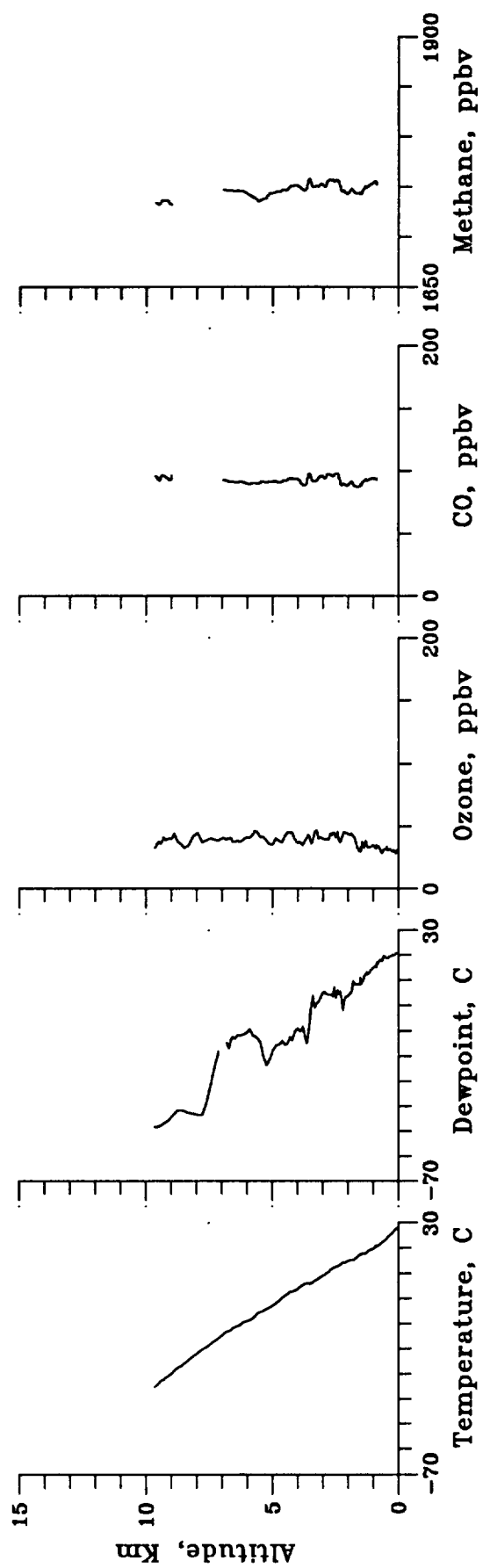


Figure A18.7



# PEM (A) PACIFIC MISSION: FLIGHT 19

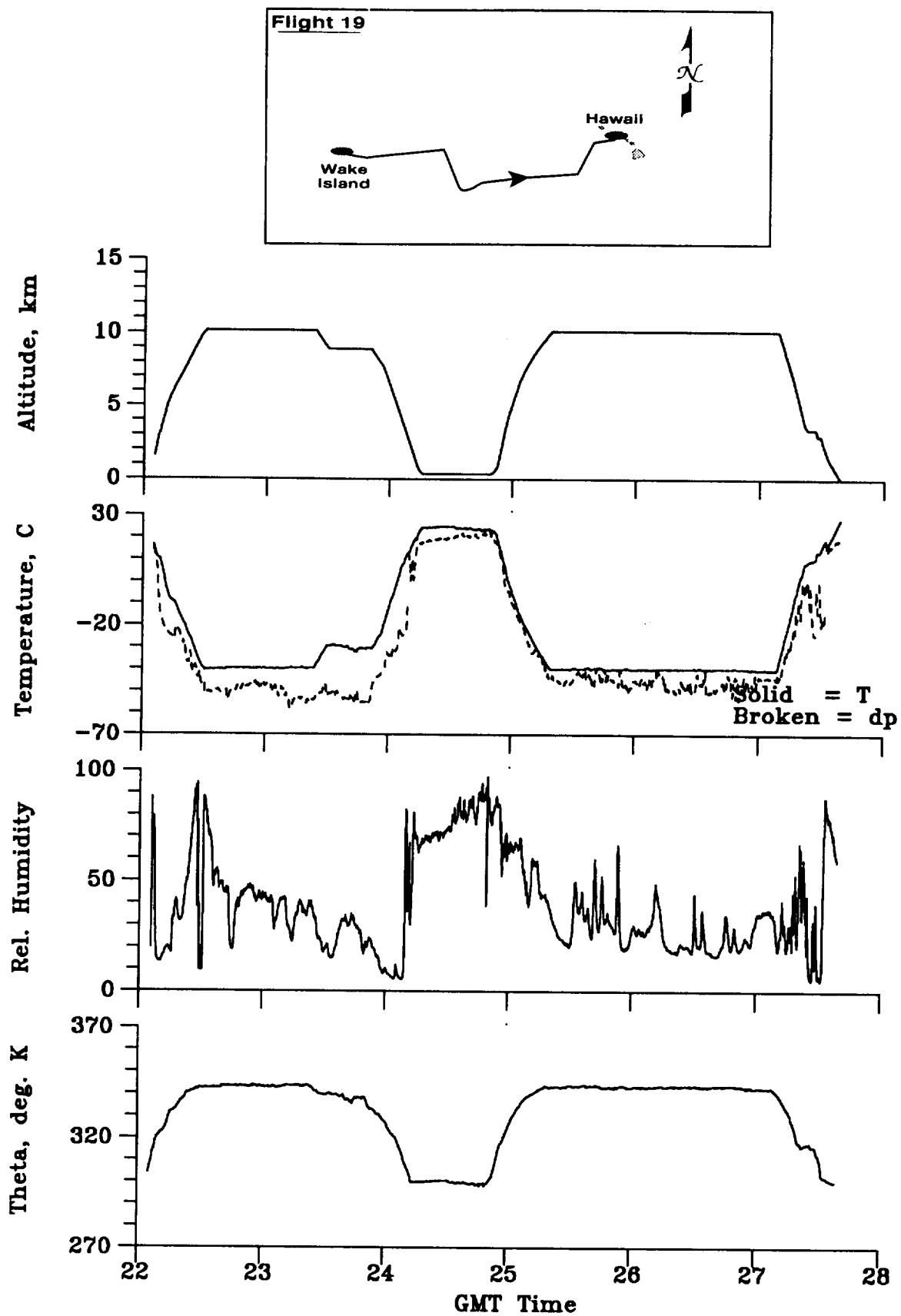


Figure A19.1

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# PEM (A) PACIFIC MISSION: FLIGHT 19

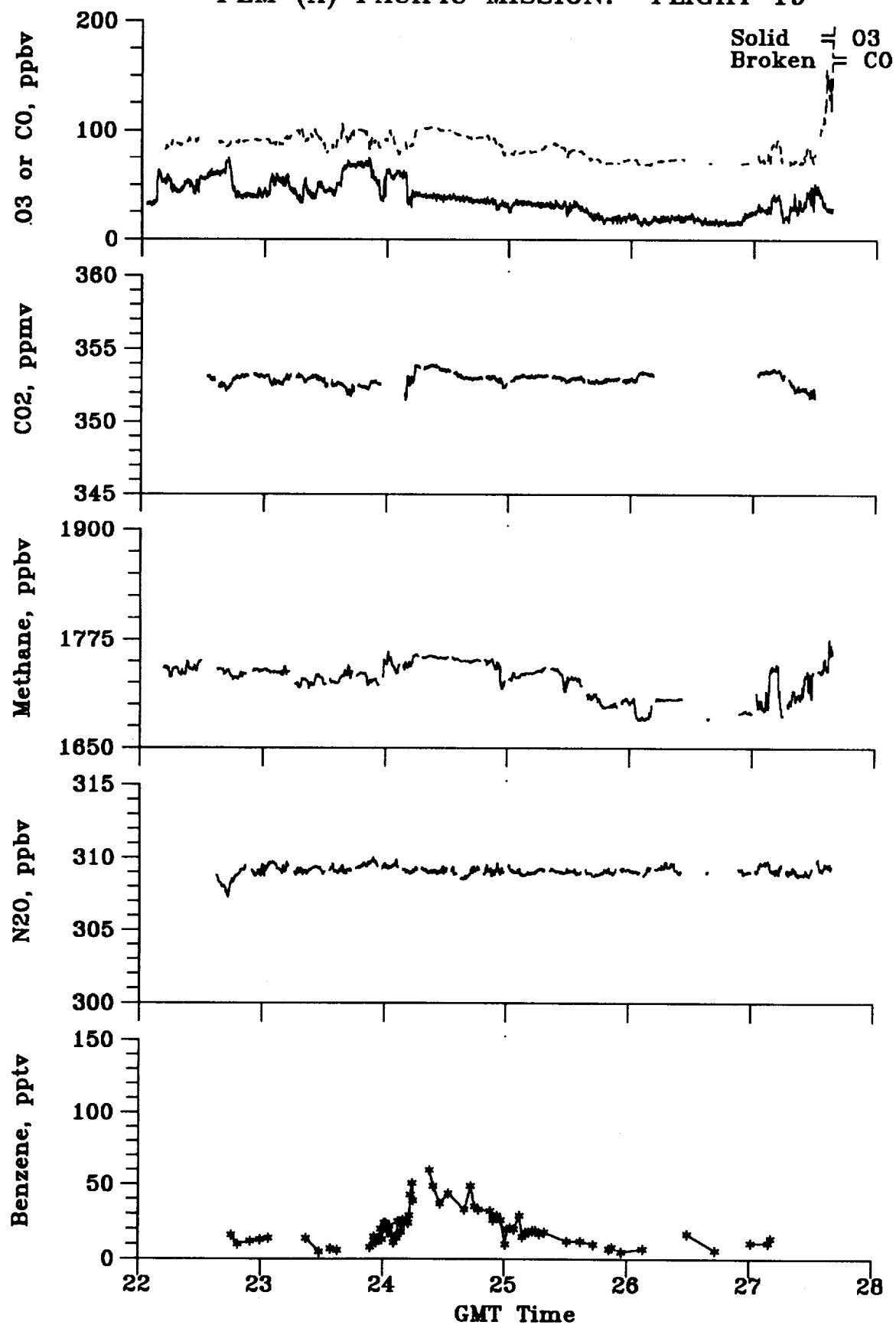


Figure A19.2



# PEM (A) PACIFIC MISSION: FLIGHT 19

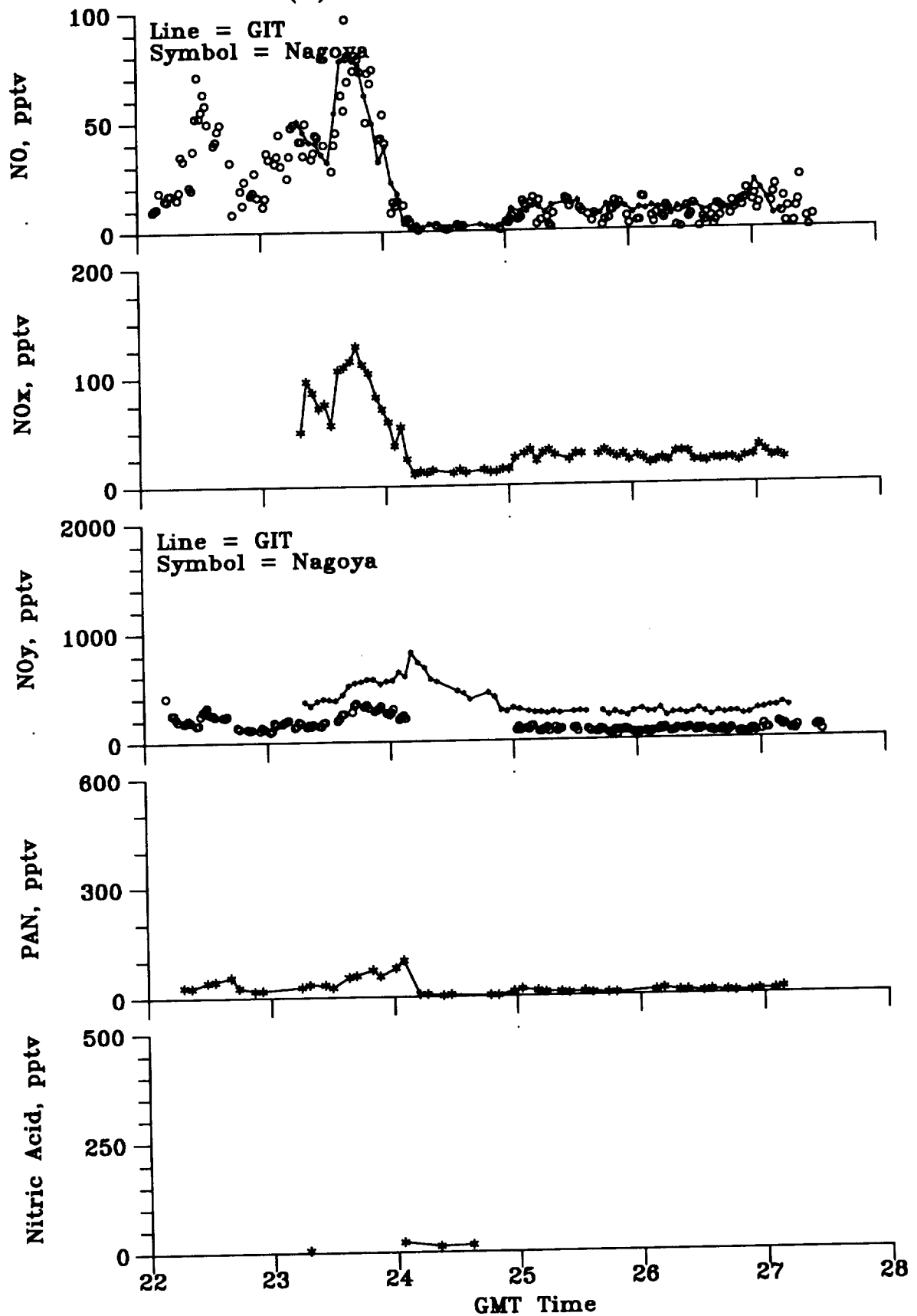


Figure A19.3

PEM (A) PACIFIC MISSION: FLIGHT 19

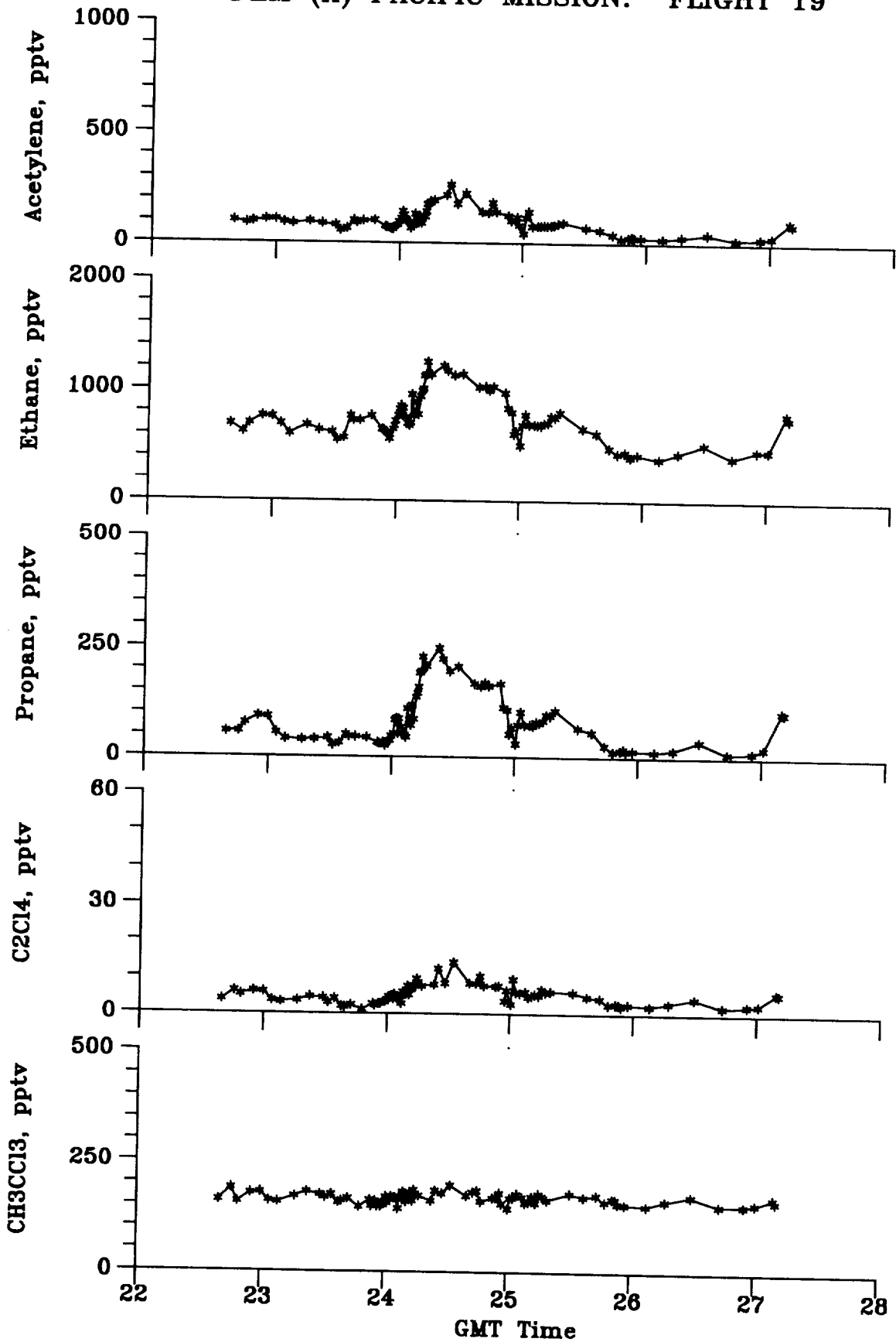


Figure A19.4

# PEM (A) PACIFIC MISSION: FLIGHT 19

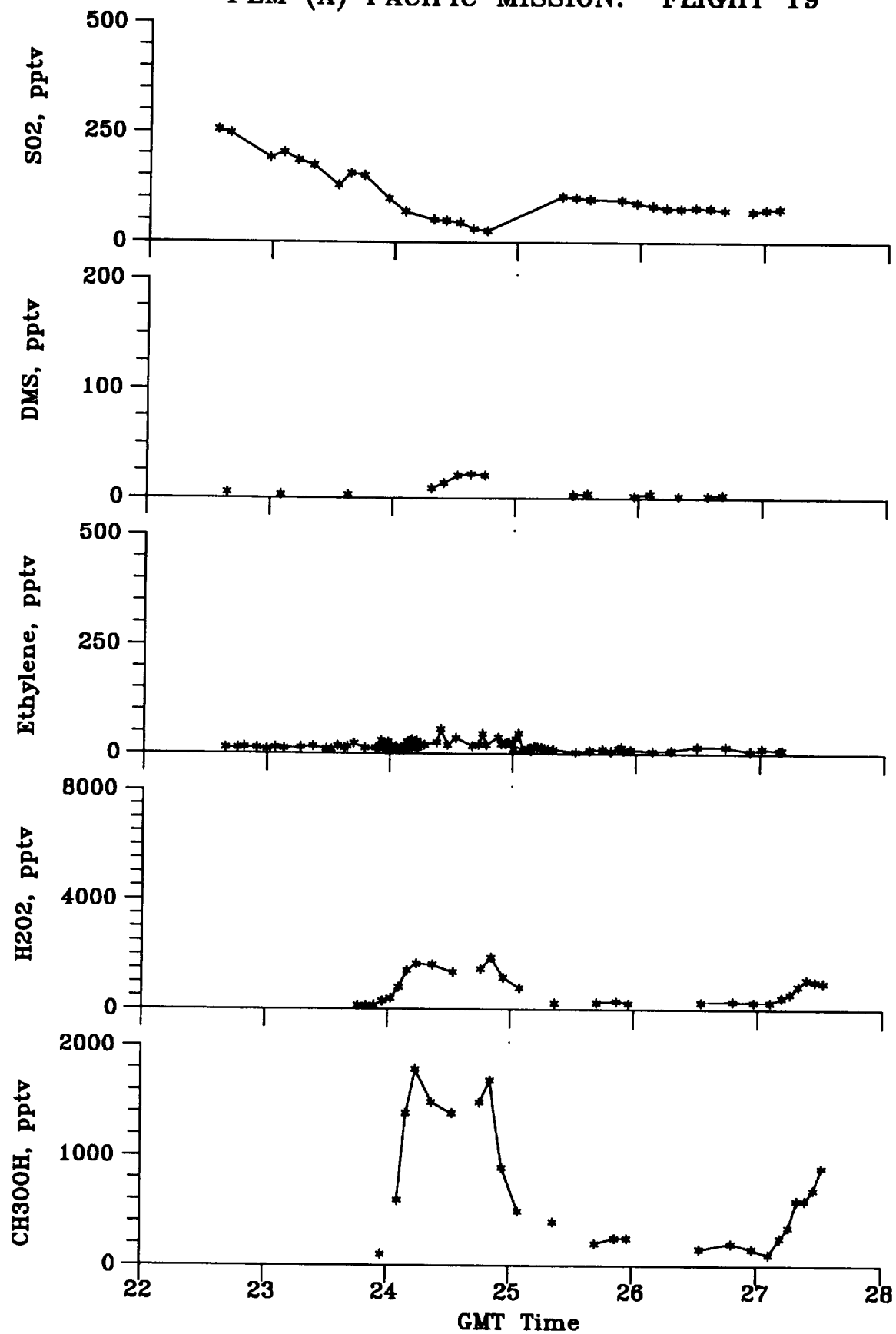
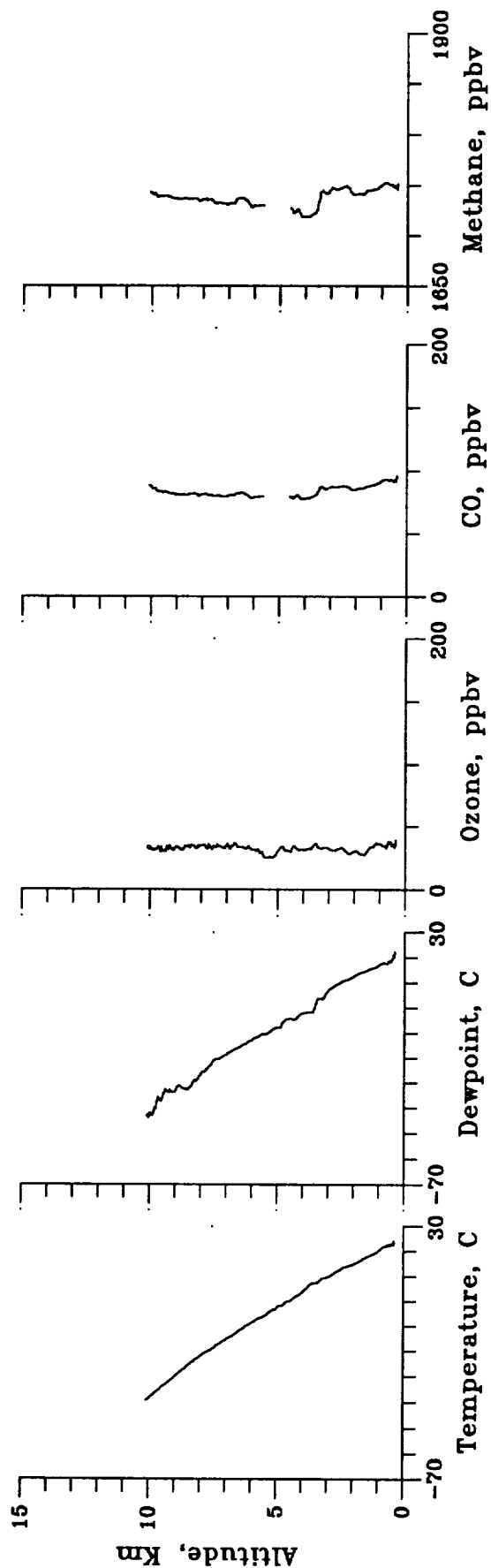


Figure A19.5

PEM (A) PACIFIC MISSION: FLIGHT 19 PROFILE AT 0100 GMT



PEM (A) PACIFIC MISSION: FLIGHT 19 PROFILE AT 0315 GMT

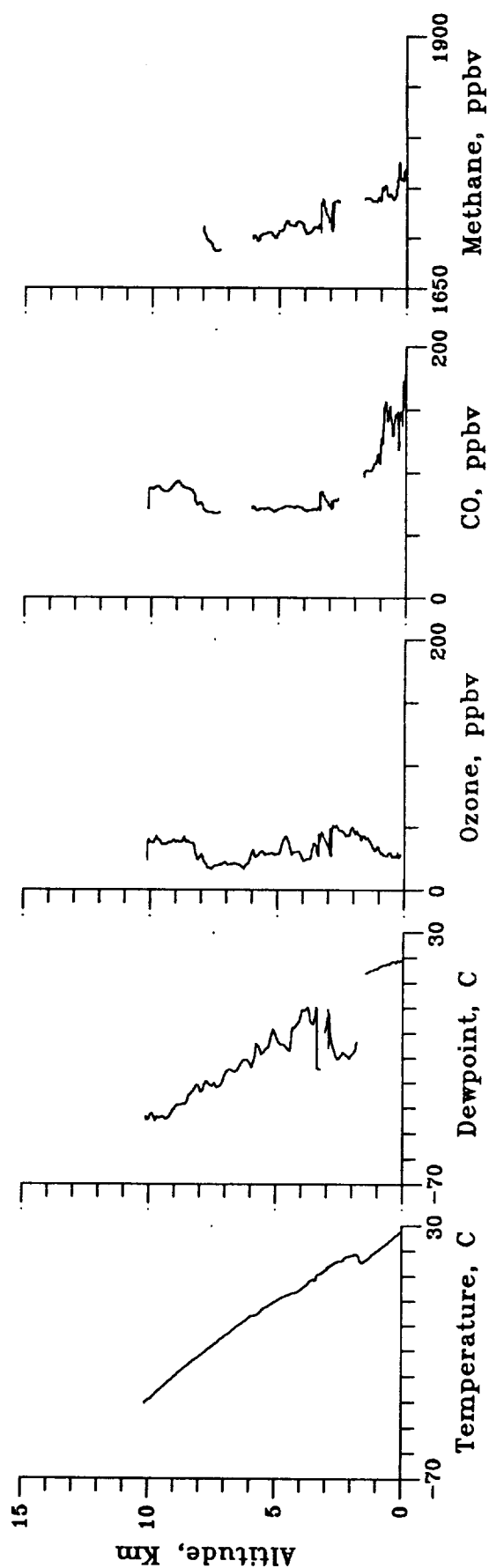


Figure A19.6

# PEM (A) PACIFIC MISSION: FLIGHT 20

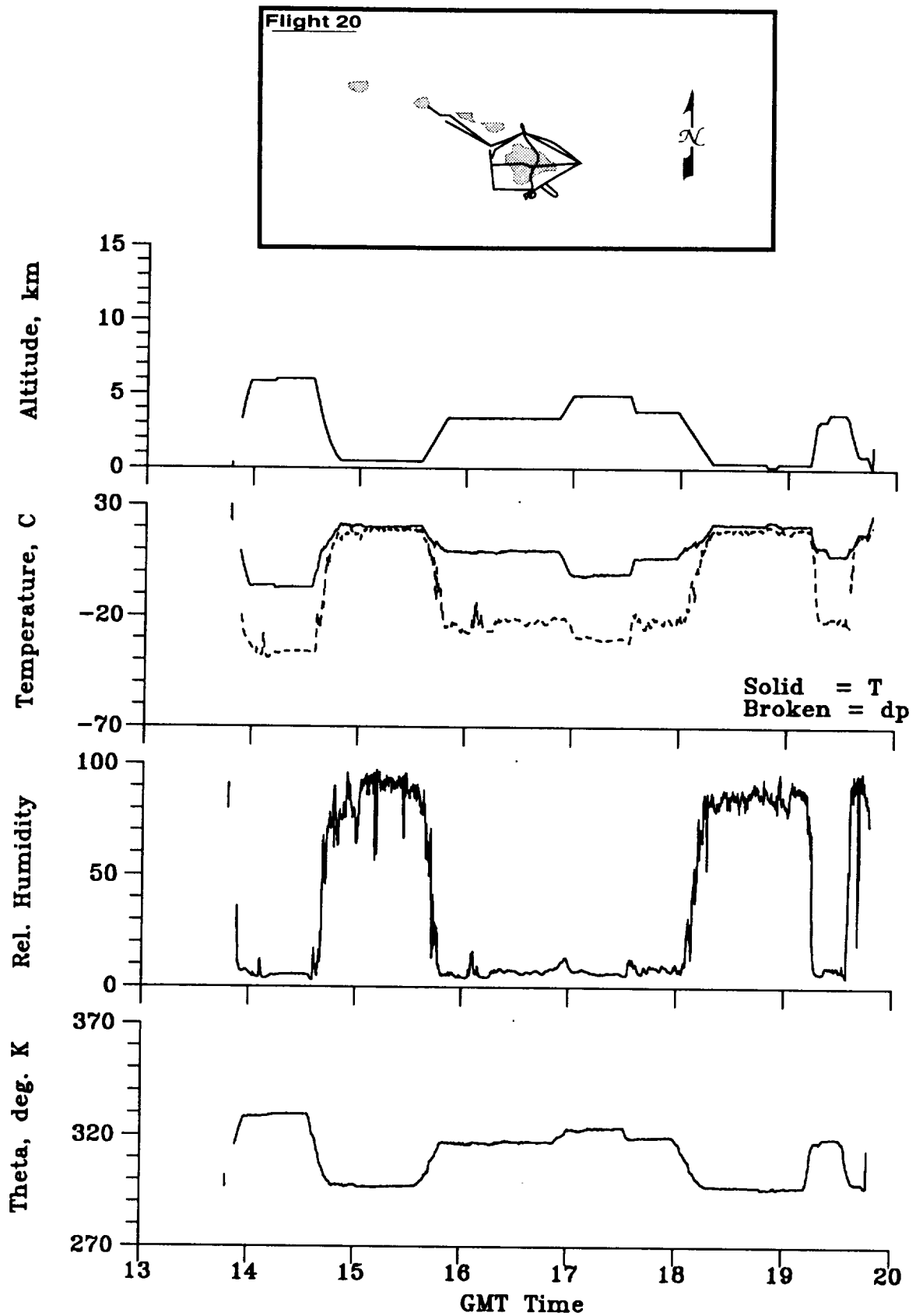


Figure A20.1

# PEM (A) PACIFIC MISSION: FLIGHT 20

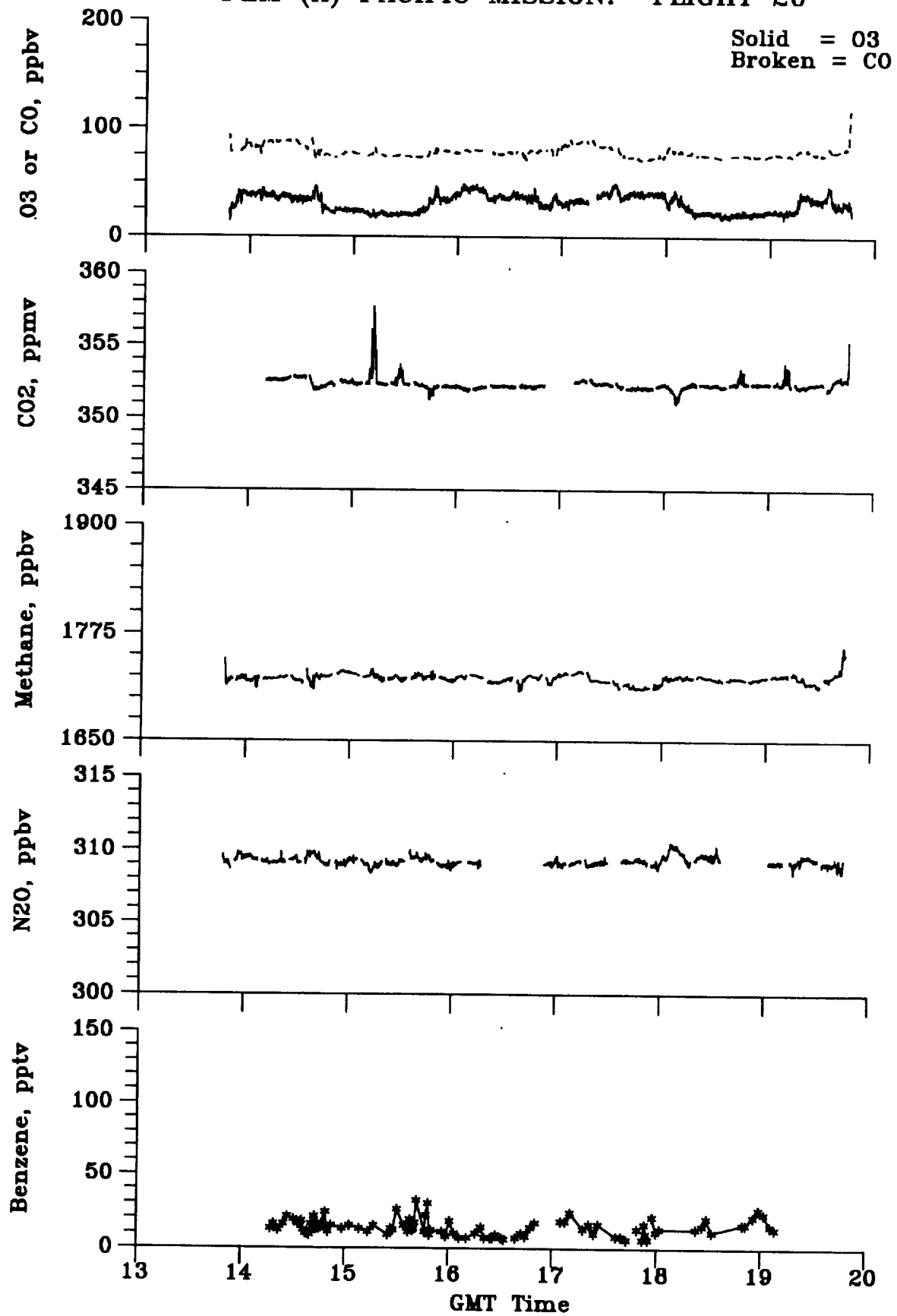


Figure A20.2

# PEM (A) PACIFIC MISSION: FLIGHT 20

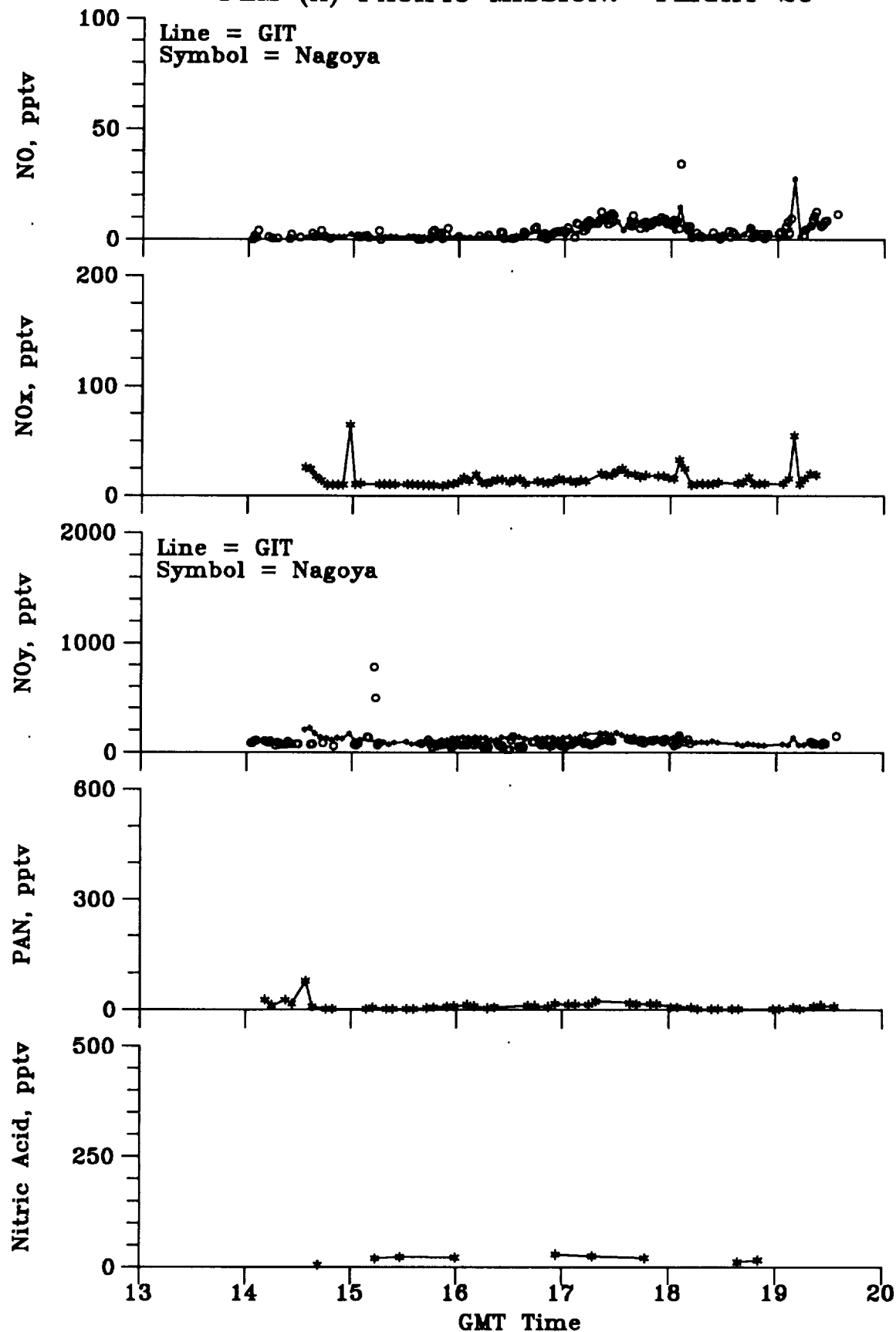


Figure A20.3

# PEM (A) PACIFIC MISSION: FLIGHT 20

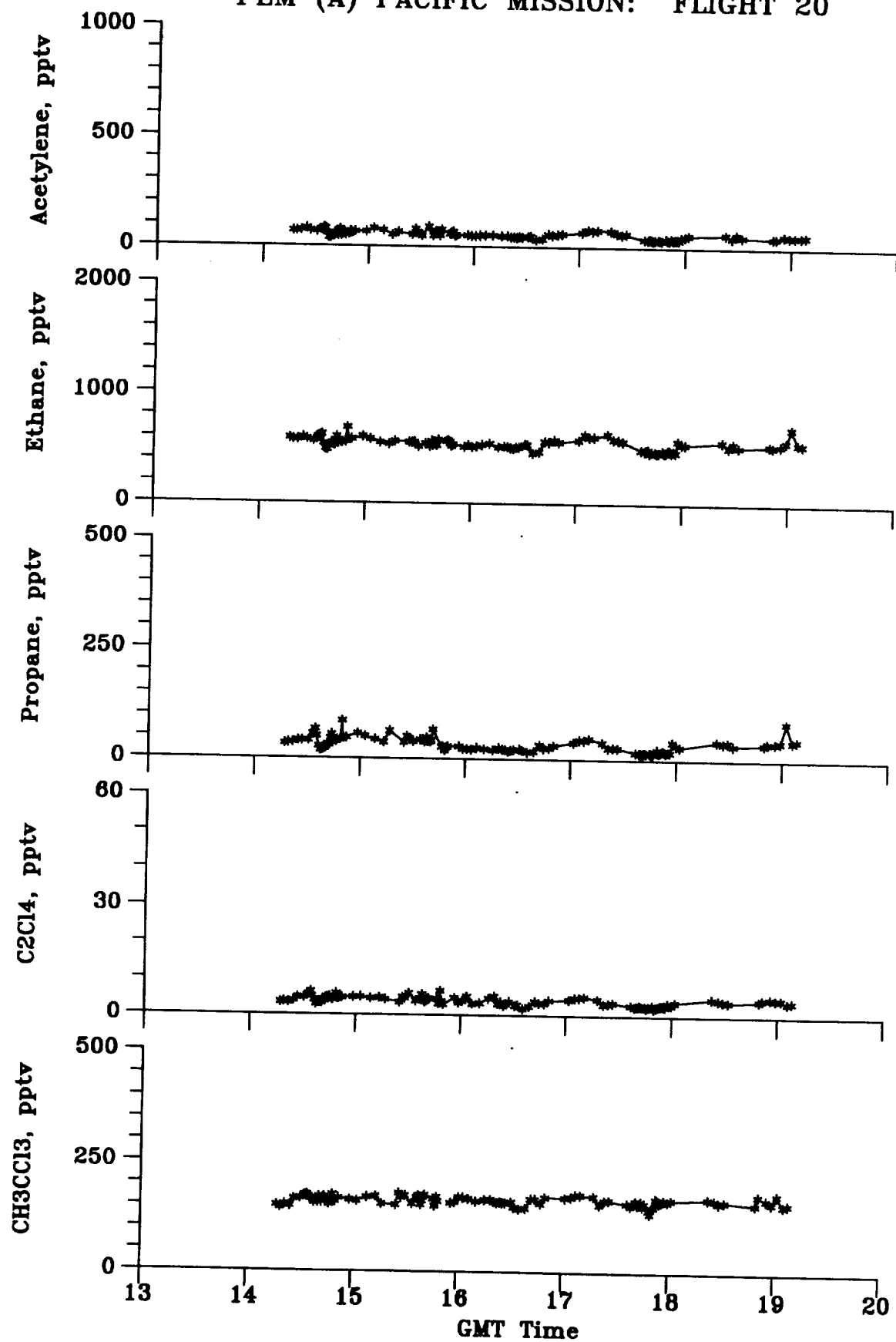


Figure A20.4



# PEM (A) PACIFIC MISSION: FLIGHT 20

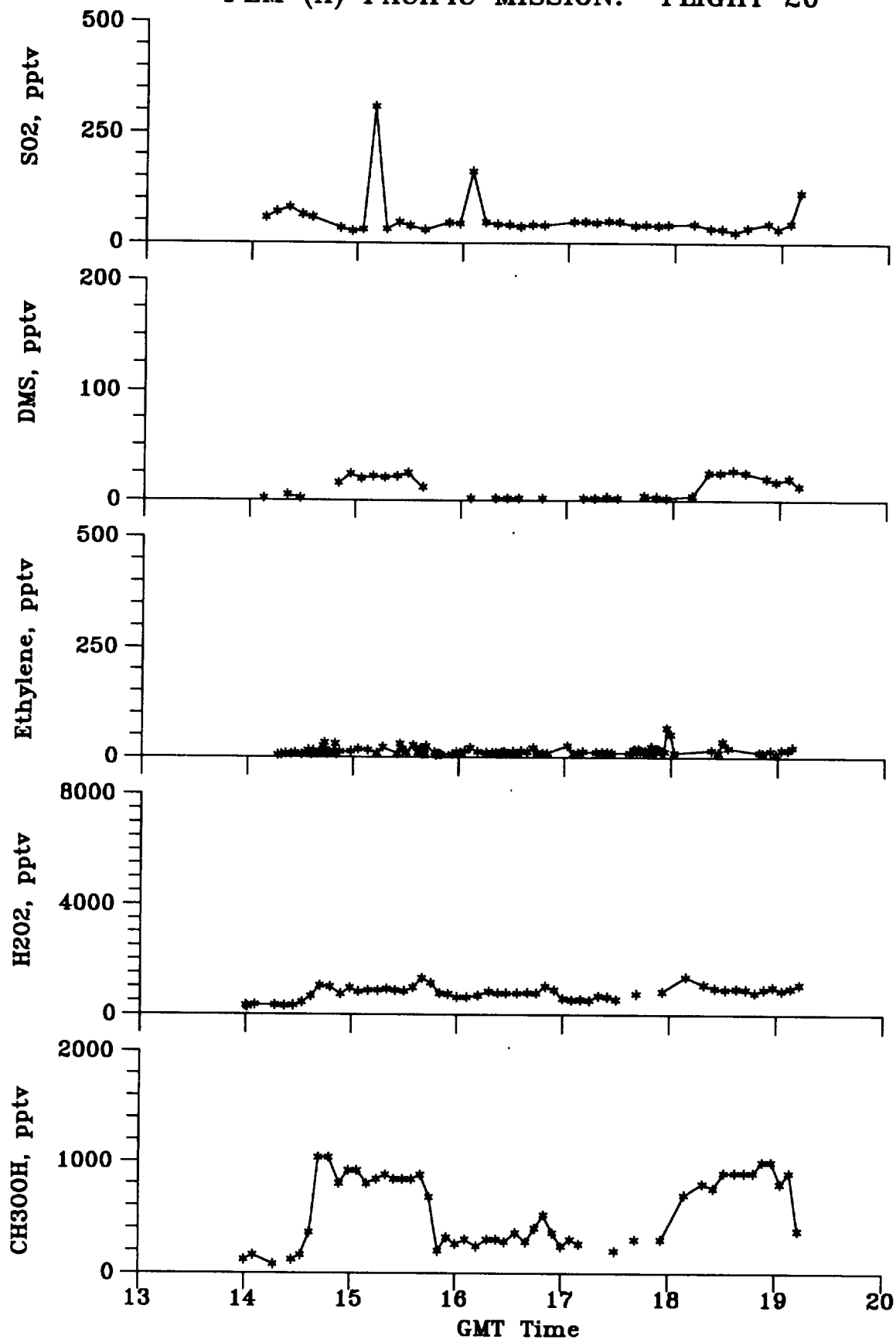


Figure A20.5

# PEM (A) PACIFIC MISSION: FLIGHT 20 PROFILE AT 1545 GMT

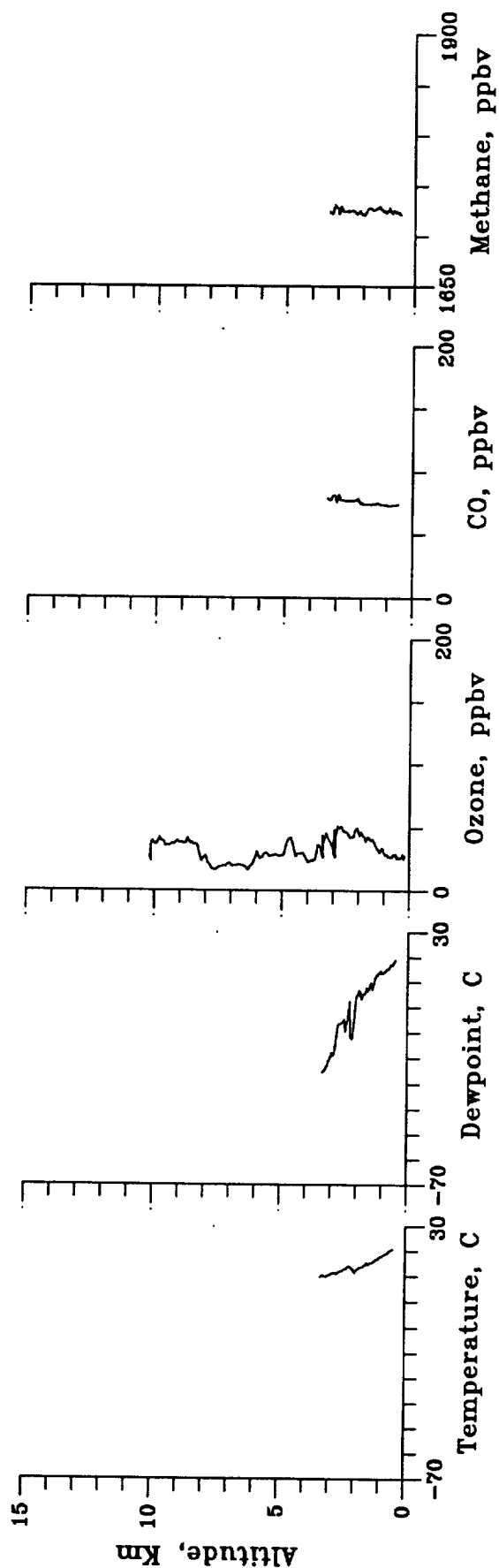


Figure A20.6

# PEM (A) PACIFIC MISSION: FLIGHT 21

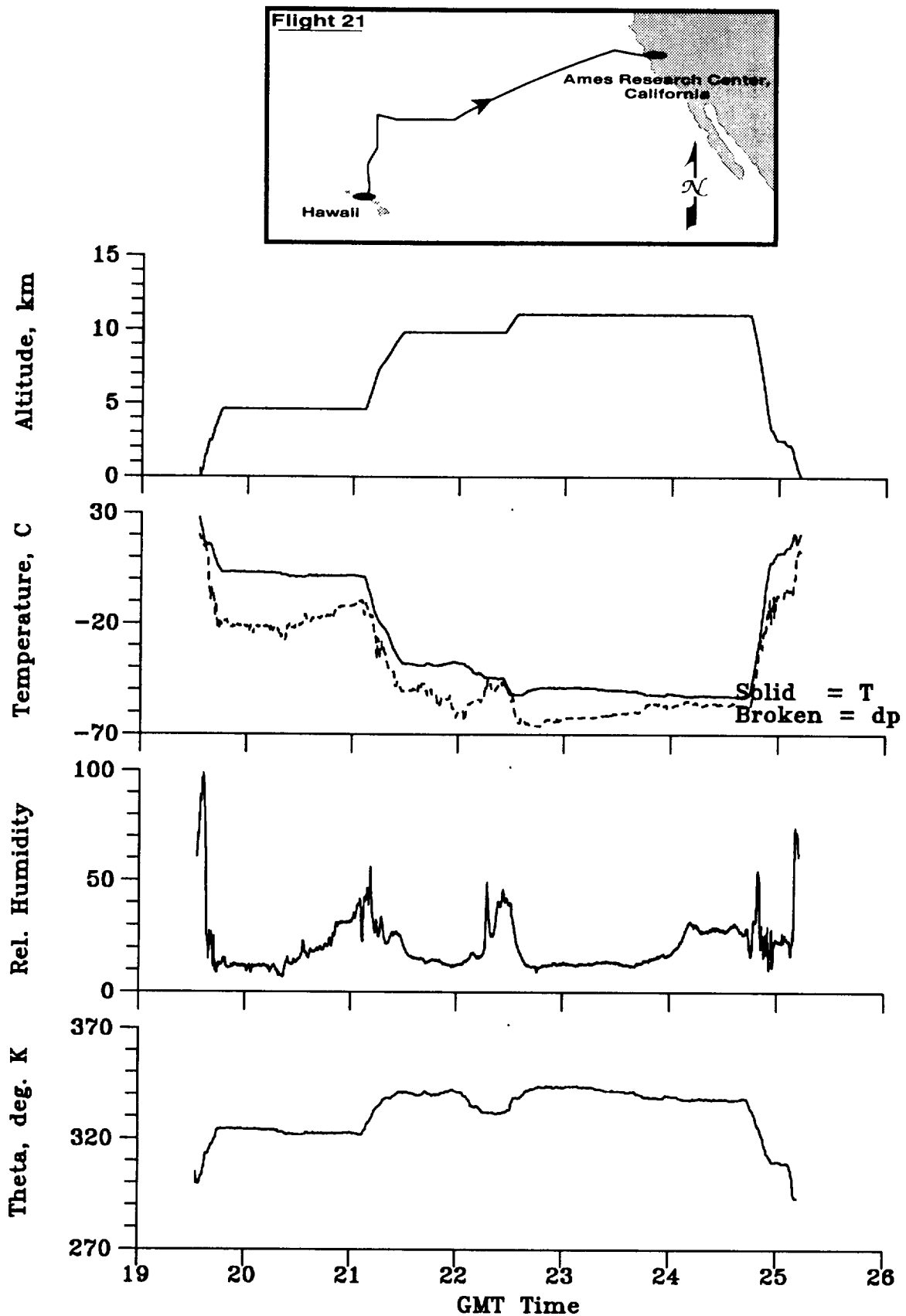


Figure A21.1

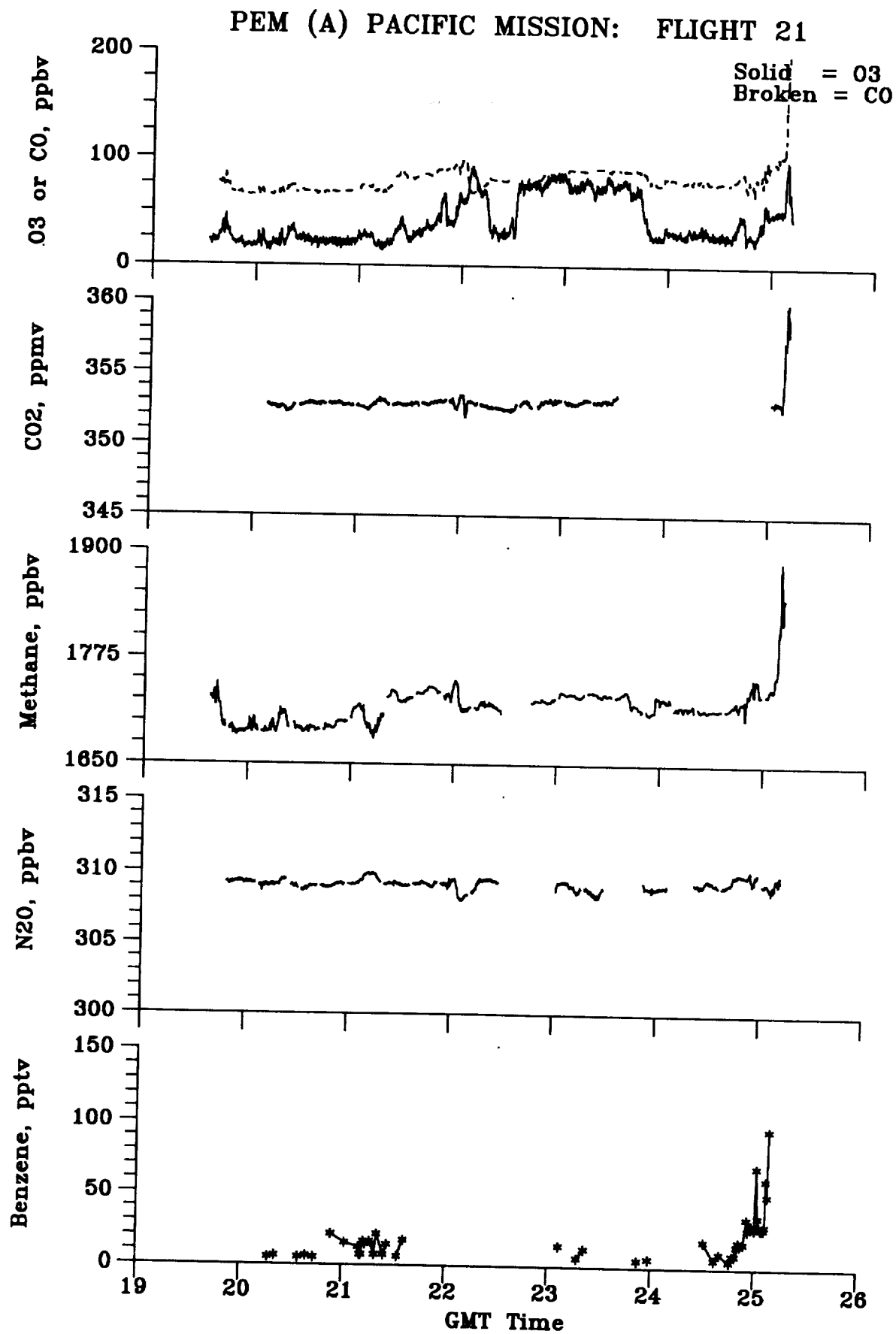


Figure A21.2

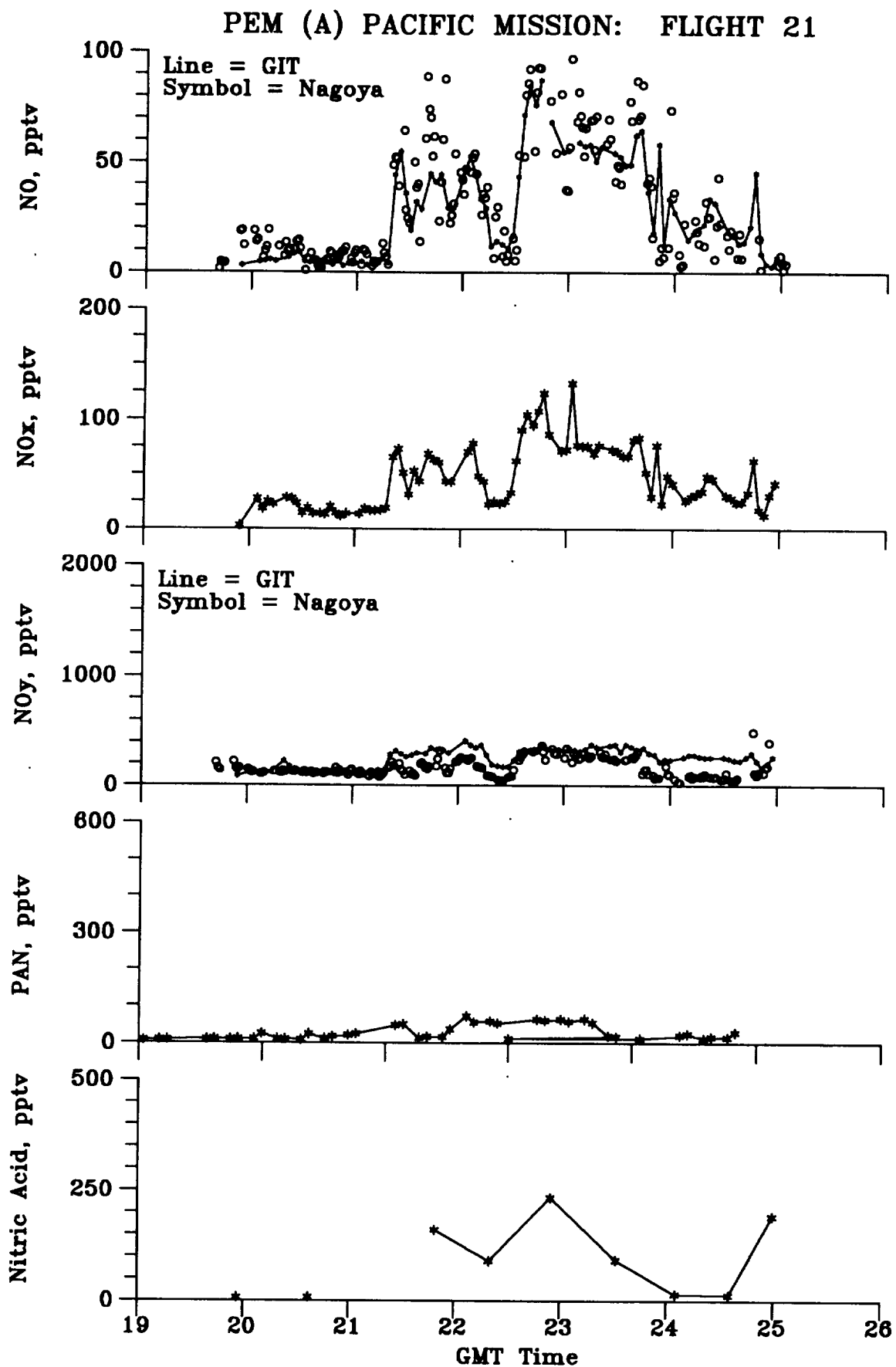


Figure A21.3

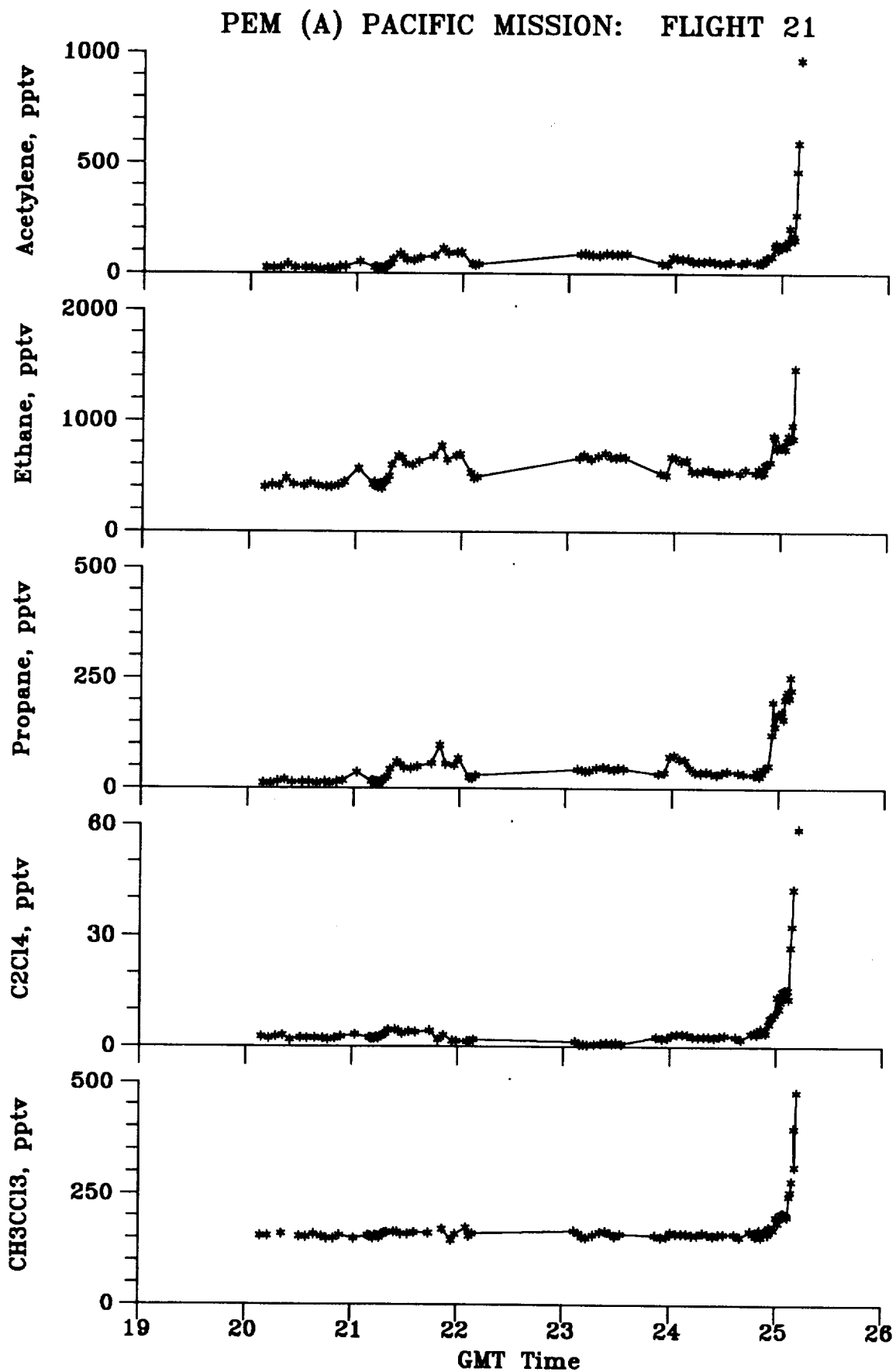


Figure A21.4

# PEM (A) PACIFIC MISSION: FLIGHT 21

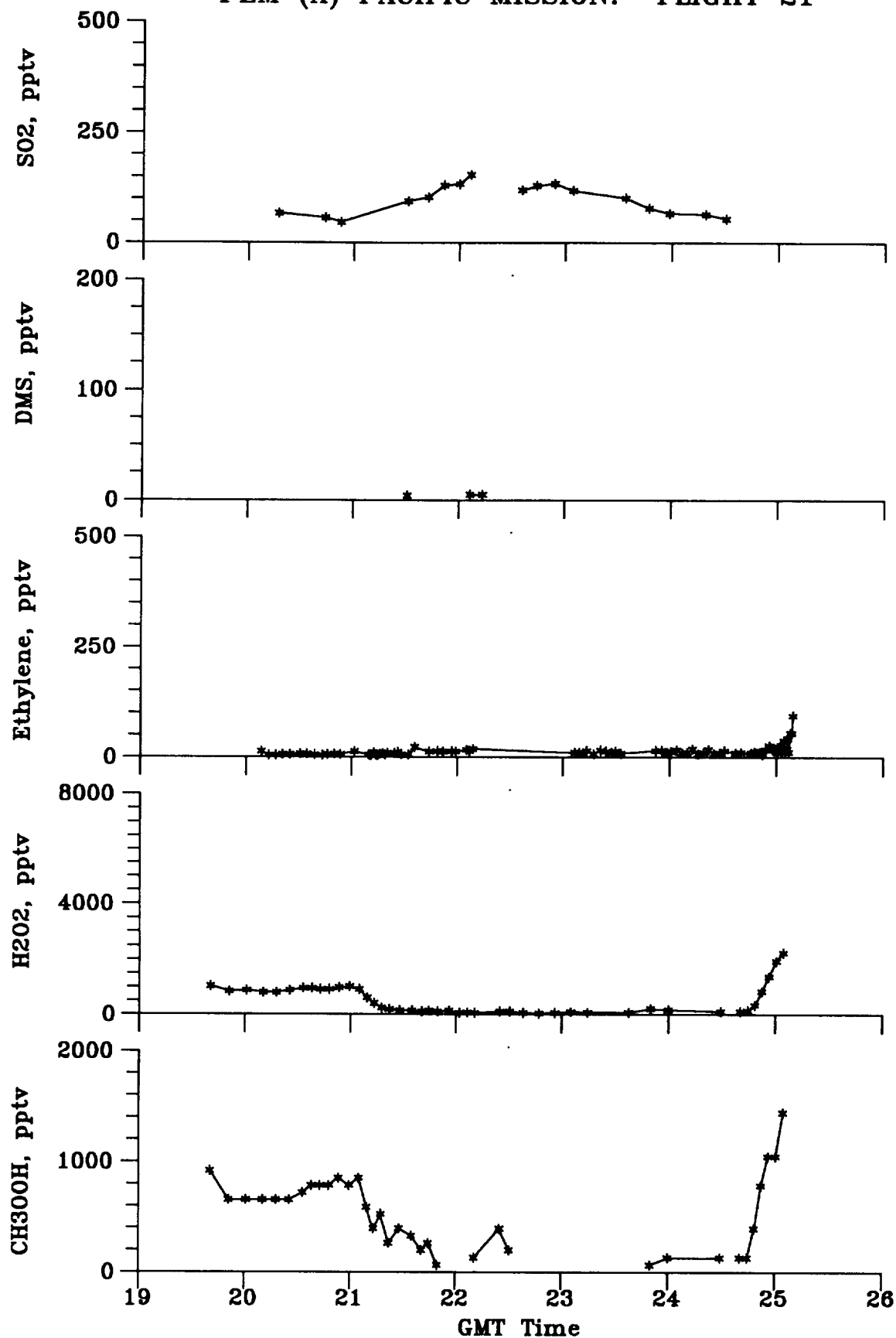


Figure A21.5

# PEM (A) PACIFIC MISSION: FLIGHT 21 PROFILE AT 1930 GMT

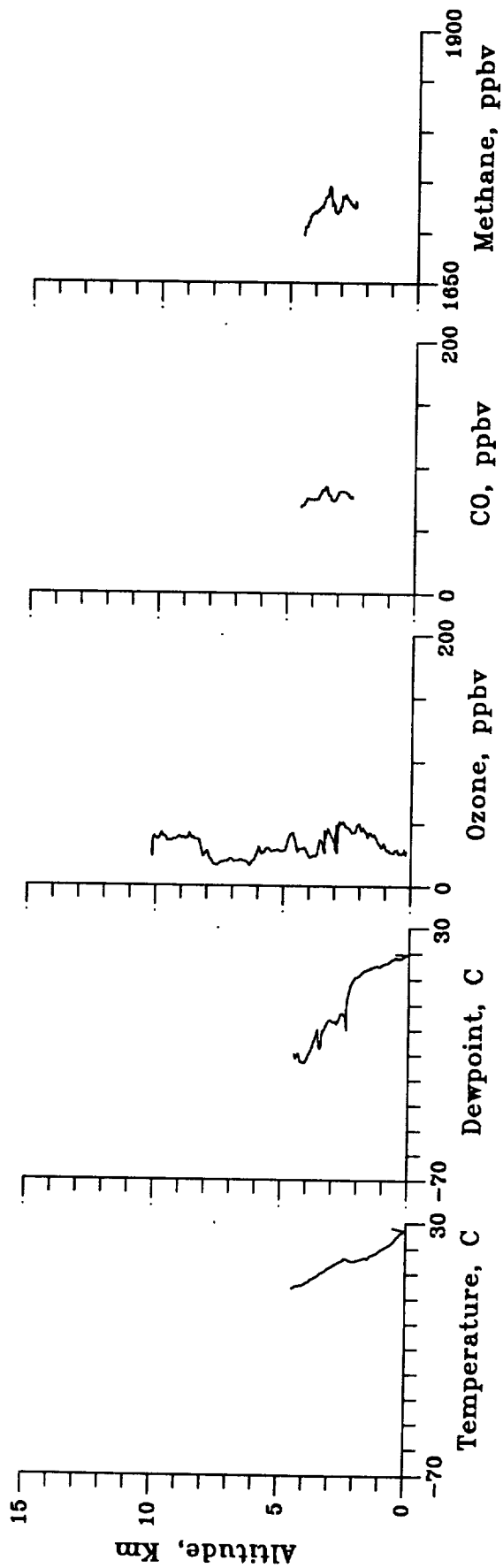


Figure A21.6



## APPENDIX B: LANGLEY DAAC DATA ARCHIVE

### System Description

The Langley Distributed Active Archive Center (DAAC), located at the NASA Langley Research Center in Hampton, Virginia, is responsible for archiving and distributing NASA science data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry. This DAAC will also archive some of the data sets which result from the EOS program and other elements of Mission to Planet Earth. The DAAC has developed an on-line computer system which allows the user to log on, search through the DAAC's data inventory, choose the desired data sets, and place an order. Data may be received either electronically (via FTP) or on media such as 4mm tape, 8mm tape, or CD-ROM (prepackaged datasets only).

### Log On Procedures

1. Users with an X-Windows terminal (e.g., Motif) or a Sun Open Windows display system with access to Internet, may log onto the system by entering:

```
xhost + eosdis.larc.nasa.gov
(or: xhost + 192.107.191.17)
telnet eosdis.larc.nasa.gov
login name:  ims
password:  larcims
```

At the prompts, enter x for the X-Windows interface and then your display name (name of your workstation followed by ":0" or Internet address followed by ":0").

2. Users with access to NCSA Mosaic can use the following URL address:

```
http://eosdis.larc.nasa.gov/
```

3. Users without access to a terminal with an X-Windows display system but who have access to Internet may log onto the system by entering:

telnet eosdis.larc.nasa.gov

login name: ims

password: larcims

At the prompt, enter c for the character interface and then press return.

4. Users who cannot access the system or who have any questions concerning the Langley DAAC may contact:

Langley DAAC User and Data Services

Mail Stop 157B

NASA Langley Research Center

Hampton, VA 23681-0001

Phone: (804) 864-8656

FAX: (804) 864-8807

email: larc@eos.nasa.gov

#### DAAC Data Bases

1. ERBE (Earth Radiation Budget Experiment)--Data were collected from three satellites (ERBS, NOAA-9, NOAA-10) carrying two ERBE instruments (scanner, nonscanner). The objective is to measure global albedo, fluxes, and solar incidence.

2. ISCCP (International Satellite Cloud Climatology Project)--ISCCP focuses on the study of the distribution and variation of cloud radiative properties. The objective is to improve the understanding and modeling of the effects of clouds on climate and also to elucidate the role of clouds in the radiation balance and improve our knowledge of the long-term global hydrologic cycle.

3. SAGE (Stratospheric Aerosol and Gas Experiment)--SAGE I gathered data concerning the spatial distribution of stratospheric aerosols, ozone, and nitrogen dioxide on a global scale. The goals of SAGE II are to determine the spatial distributions of stratospheric aerosols, ozone, nitrogen dioxide, water vapor, and cloud occurrence by mapping vertical profiles and calculating monthly averages of each.
4. SRB (Surface Radiation Budget)--The SRB data sets were calculated using inputs from ISCCP and ERBE data. They are designed to give global daily and monthly averages of the albedo, irradiance, cloud properties, and meteorology.
5. FIRE (First ISCCP Regional Experiment)--This series of experiments includes aircraft, satellite, and surface-based measurements of cirrus and marine stratocumulus cloud parameters. The purpose of this program is to validate and improve ISCCP data products and cloud/radiation parameterizations used in general circulation models (GCMs).
6. GTE (Global Tropospheric Experiment)--Data were collected primarily from aircraft and ground-based instruments from a variety of areas such as the Amazon Rain Forest and the northern tundra and boreal forest. Many parameters were measured including  $O_3$ ,  $CH_4$ , PAN, CO, NO,  $NO_2$ ,  $CO_2$ , and aerosols.
7. MAPS (Measurement of Air Pollution from Satellites)--Data were collected during Space Shuttle flights in 1981, 1984, and 1994. The main pollutant measured was carbon monoxide (CO).
8. SAM II (Stratospheric Aerosol Measurement)--This instrument was flown on board the Nimbus-7 satellite and consisted of a one-spectral channel Sun photometer, centered at 1.0  $\mu m$ , which viewed a small portion of the Sun through the Earth's atmosphere during spacecraft sunrise and sunset. The data obtained from this instrument were used to determine the vertical distribution of stratospheric aerosols in the polar regions of both hemispheres.

|  |   |  |   |  |
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